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ABSTRACT

This guide is intended to provide educators responsible for selecting elementary science curriculum materials for high ability learners with both quantitative and qualitative assessment data for 27 science curricula or materials. The review process attempted to balance sound practices of curriculum development (using standards required for any exemplary curriculum and any population), exemplary science practices (based on "new science" recommendations), and differentiation issues for high ability learners and other special populations. Introductory material of section I explains how to use the guide, how to integrate the guide with school and district goals, the categories of the reviewed curricula, and instructional emphases of curricula (e.g., reading based, inquiry based, interdisciplinary). Section II then provides evaluations of 13 comprehensive stand-alone curricula series. Section III evaluates seven modular programs and section IV offers evaluation of seven sets of supplementary materials. Each evaluation includes a narrative overview, an analysis, a conclusion, and results of comparative ratings by several reviewers. Appendices provide: a compilation of curriculum review ratings; the curriculum review process and criterial rating sheets; and an annotated 70-item bibliography of science curriculum materials. (DB)

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CONSUMER'S GUIDE TO
SCIENCE CURRICULUM

by

Linda Neal Boyce
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Section 1 Overview

The purpose of this guide is to provide state, regional, and local educators who are responsible for selecting science curriculum materials for high ability learners the most up-to-date information regarding appropriate materials for these learners. Both quantitative and qualitative assessment data were gathered for each of 27 materials selected for review and are presented in the guide. Recommendations for use of the materials are also included based on key features and special population characteristics.

All educational personnel interested in innovative science curriculum will find the in-depth analysis of these materials of great interest and assistance in curriculum planning for all learners at K-8 levels.

The basic notion that underlies all new science programs is the belief that in inquiry the information or relevant cues lie hidden in the materials and not in the head of the teacher.

Mary Budd Rowe
from "Science, Silence, and Sanctions,"
Science and Children, 1969

Introduction and Rationale: Science Curriculum Review

The task of evaluating science curricula for appropriateness with high ability students becomes critical in the context of national reform in science education. Several national organizations such as the American Association for the Advancement of Science and the National Science Teachers' Association have called for all science education to make fundamental changes both in content and in presentation of material. Depth of conceptual understanding takes precedence over breadth of factual coverage in the recommendations, in recognition of the rapidly expanding information base in science. All students should also be exposed to the nature of science, especially the practice of the scientific method and the attitudes of reasoned skepticism and tolerance of ambiguity associated with scientific thought. Changing the factual and didactic orientation of the current curricula to meet these new goals will require changing the very structures and foundations of the curriculum itself; a change in paradigm.

Two challenges are presented to reviewers of curricula who accept the validity and necessity of the "new science" regime. The first is to find a fair way to rate current science curricula while attending to the assumption that in order to be effective, science instruction will have to follow a significantly new form. Basal texts which may be evaluated as perfectly sound under the old paradigm may in fact look less promising when rated using "new science" standards. Nevertheless, such a review provides part of the demonstration of where and how changes need to be made to meet the demands of the 21st century.

The second challenge is to find a new and unique set of standards for determining differentiation for high ability students. The AAAS report 2061: Science for All Americans outlines scientific content, processes and attitudes which should be cultivated in all American students. This list, new to the goals of most general education programs, looks very much like the list of goals which teachers of the gifted have held for their students for some time. If all students should learn science concepts, learn to act and think like scientists, learn to independently hypothesize and experiment and analyze and infer, then what will the new set of goals for gifted students be?

A good core curriculum is an absolutely essential foundation of exemplary science instruction. Because of the interest in engaging students in science for the long term, it has become increasingly important to select or create science curriculum which simultaneously achieves several goals:

- The delivery of content which is substantive, up-to-date, and essential to an understanding of one or more science fields;
- The demonstration of science practices and "habits of mind" to give students practice in the behavior and thinking of scientists;
- The delivery of content and processes in a context which excites and entices students without diminishing the value of the content or reducing the practice of science to games or "magic."
- The opportunity for students to make connections between science areas and between science and other areas of study.

While such a core curriculum emphasis is essential for all learners, differentiating for the high ability learner requires responding to the scientific interests and behaviors displayed by

these learners. These behaviors include: early curiosity and understanding about the world of science; ability to master the tools of science by demonstrating the activities, beliefs, and characteristics of scientists; ability to reason analytically, deductively, and inductively with more complex material; and the energy and persistence to solve real problems of science. Thus, high ability learners need advanced science content earlier and at a more complex and abstract level than do other learners, even under the new science model.

Our goal for assessing science materials is to create a fair balance among sound practices of curriculum development, exemplary science practices, and differentiation issues for high ability learners. Three phases of review were created to provide this balance. In Phase I, general curriculum features are analyzed working from the assumption that there are standard elements which must be present in any exemplary curriculum in any paradigm and for any population. The "new science" paradigm is reflected in Phase II of the review which was crafted around the recommendations of major science reform reports and input from scientists. Together, these criteria create a powerful guide for the review of any science curricula, including basal texts and ancillary materials. The Phase III criteria for differentiation for special populations reflects an existing synthesis of approaches to modifying curriculum for high ability learners. Special considerations are also noted for students who are intellectually gifted, girls, minority, and disabled students.

To facilitate the process of curriculum review, and especially the interpretation of the ratings derived from the reviews, two parallel products were created to accompany the Phase I, II, and III criterial rating forms. The first is a "consumer's guide" form which encapsulates the fundamental findings from the criterial rating sheets. Overall judgments reached from the rating can be compared across curricula using this standard form for quick reference. The second product is a narrative review which provides substance and context to the codified information provided through the consumer's guide form. Although the substance of the narrative, like the consumer's guide forms, is derived directly from individual rating sheets, its format allows for a more comprehensive discussion of a curriculum's strengths and weaknesses.

Because curriculum materials are considered so crucial to the enterprise of science teaching, we believe that this Consumer's Guide to Science Curriculum should be reviewed by all school districts in the country who are interested in science learning for high ability students. The users of this guide may be 1) curriculum developers, 2) district-based curriculum or textbook review committees, or 3) individual teachers interested in materials review for classroom use. We hope the process conveys a reasonable approach to decision-making about educational materials in science and that practitioners will find it helpful.

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Who Should Use This Guide?

The guide is intended for use by multiple educational audiences that include administrators, gifted program coordinators and classroom teachers. Many times the guide may be useful as a tool for planning a science program within a school district where these individuals come together to select materials in a collaborative manner. Textbook adoption committees at both state and local levels should find the guide extremely useful. The audiences for this guide and the purpose for which they might use it are described below:

Administrators

- to select basic texts for all students, in the context of also serving their high ability students
- to conduct an initial review of science curricula based on school or district goals
- to stay informed about options in science education which extend the current school practices

Gifted Program Coordinators

- to provide substantive programming in science for high ability learners
- to program for high ability learners in the context of science reform and school/district science goals
- to become capable of providing informed advice to the regular classroom teacher on how to use materials to differentiate for high ability students

Classroom Teachers

- to understand the options in programming in science for all students
- to make informed comparisons between resources and make sound recommendations to program coordinators and administrators
- to assist in the flexible adaptation of a program or course of study by augmenting it with a variety of quality resource materials.

How to Use This Guide

Contents

Our goal in constructing this guide was not to identify the single "golden curriculum" which would serve the needs of all teachers, all students, or all school programs. Instead, our intent was to compare the relative strengths and weaknesses of the various curricula which are currently available, based on rigorous and up-to-date standards. Similarly, we did not intend to provide a "thumbs up" or "thumbs down" ruling on individual curriculum but rather we wanted to provide a thorough description of the individual components of each curricula relative to curriculum construction, science content and process, and appropriateness for high ability students. To capture the full depth of the review, each curriculum report is composed of three sections. First, a **narrative review** provides a detailed description of each curriculum piece reviewed along with a critical description of its attributes in the areas of curriculum instruction, issues associated with exemplary science curricula, and appropriateness for special populations, and in particular, for high ability students. Second, a **summary of the numerical ratings** assigned to each part of the review criteria provides a more objective sense of the review team's relative sense of the curricula's merits. Finally, a **"consumer's guide"** encapsulates the fundamental findings from the criterial rating sheets so that ratings in individual categories can be compared across curricula using a standard form for quick reference.

Interpreting the Guide

The curriculum review process was constructed to provide three interrelated perspectives, creating a prismatic lens for looking at curriculum. To be most effective, the three components must be used together. It is especially important that the numerical ratings not be used in isolation from the narrative review or the consumer's guide summary. The numerical ratings represent an average of the three reviewers' judgments. Like all averages, the summary averages presented on the charts represent a distribution of scores, and not a single definitive judgment. Indeed, in the case of many reviews the differing perspectives of a scientist, an educator and a materials specialist raised unpredictable concerns which resulted in a wide range of ratings--and some pretty lively debate! In a similar vein, the summary statistics, being intentionally objective, do not communicate important qualitative information about the special features of the program which can only be described in the narrative review. Often a curricula or program which did not receive high ratings had wonderful elements which were not captured by the checklist; these noteworthy additions are described in the narrative text. Therefore, we caution readers to use all components of the review as they compare curricula reviews in this document.

Another important consideration associated with these reviews is the environment in which the review was conducted. The entire review process was confined to the analysis of print (or visual) materials. No effort was made to rate the implementation of the curriculum or to watch it being used in the classroom. The reason for this was simple: when watching implementation of a curriculum, issues of curriculum structure and design become interwoven with issues of pedagogy and skill of delivery. However, because the ratings were made independent of teacher skill and classroom observation, it is important to stress that the ratings only reflect the

potential of the curriculum as it appears in its marketed format. Time and time again reviewers noted that the best curricula were dependent on knowledgeable and skillful teachers to bring the full potential to life. Novice or otherwise inexperienced teachers may not be able to bring the full promise of an individual curriculum to fruition. Likewise, a very skillful teacher may be able to take a less exemplary curriculum and, by adding interesting questions or lively discussion, infuse it with unexpected life.

Integrating the Guide with School and District Goals

Different school districts and programs have different goals--as well they should. As a result, administrators or teachers from different school districts will likely value different qualities in a curriculum. Where one may be looking for inquiry-based materials, another may be intent on finding hands-on materials. For some, issues of science process may supercede issues of science content; for others, the reverse may be true. This guide should allow for a quick look at the fundamental qualities of individual curricula and help make some "first round" choices based on a combination of school or district goals and the criterial ratings.

As suggested above, to use this guide to its fullest potential the reader will have to first be familiar with the goals of his/her own individual program. By matching the school or district's program goals with our own review criteria, the reader could then identify which of the components of the review and criterial rating summaries will be most important to her individual purposes. Reading for this specific information will help identify a number of curricula or materials which are worthy of more in-depth scrutiny. By following the steps listed below, the reader should be able to read the narrative curriculum reviews most intelligently:

- 1) Identify the goals and desired outcomes of your program.
- 2) Identify the overlap between your goals and the review criteria used in this guide.
- 3) Use the points of overlap to find highly rated curricula in which you may be interested.
- 4) Read the reviews and identify the curricula which best meet your needs.
- 5) Order those curricula which best match your needs as a school district.

It is important to realize that this series of curriculum reviews serves only as a first step in the systematic identification of curriculum materials. Nothing can substitute for a comprehensive scrutiny of the actual texts. Our hope is to help teachers, gifted program coordinators and other school administrators "narrow the field" as they first enter the curriculum selection process.

Categories of Reviewed Curriculum

The following set of reviews of selected science curricula are based on the evaluation criteria described in Appendix B. Although varied, we do not claim that the list of reviewed curricula is complete; we do, however, believe that it is a sound representation of the currently available curricula. The materials are divided into three sections, as defined below:

- 1) **Stand-alone/ comprehensive texts** are intended for a particular age group or grade level. They are designed to present a students' total science program for a school year and are often adopted by a school system for all science instruction in grades K-6 or 6-8. Generally these curricula are written for and marketed by the major educational publishing houses.
- 2) **Modular curricula** are packaged in independent units that are organized around large topics or concepts. They include elements of well designed curriculum such as objectives, activities, sequence of content, and assessment measures. The modules may be used in two ways: a) the units may be selected to design a customized, full-year curriculum or b) individual units may be selected to enrich or replace portions of existing curriculum.
- 3) **Supplementary materials** are comprised of loosely connected activities or fully developed units that enrich existing curriculum. These pieces generally have a very precise focus, rather than a full treatment of science.

Table 1 provides a summary of the categories in which each curriculum was placed. To allow for the flexible nature of some of the programs reviewed, the chart shows both the primary structure of the curricula and other possible classifications where appropriate.

Table 1: Categorization of Reviewed Curricula

	Stand Alone/ Comprehensive Curriculum	Modular Program	Supplementary Program
AIMS (Activities to Integrate Mathematics and Science)			X
Biological Science: A Molecular Approach (BSCS Blue Version)	X		
Challenge of the Unknown			X
CEPUP (Chemical Education for Public Understanding)		X	*
Discover Science (Scott Foresman)	X		
ESS (Elementary Science Study)		X	*
Focus on Science (Merrill)	X		
FAST (Foundational Approaches to Science Teaching)	X		
FOSS (Full Option Science System)	*	X	
GEMS (Great Explorations in Math and Science)	in development	X	*
Insights	in development	X	
LEGO Logo		*	X
Life/Physical/Earth Science (Prentice-Hall)	X		
Middle School Life Science (Kendall/Hunt)	X		
National Geographic Kids Network	in development	X	*
SAPA (Science--A Process Approach)	X	*	
Science and Technology (Harcourt, Brace, Jovanovich)	X		

	Stand Alone/ Comprehensive Curriculum	Modular Program	Supplementary Program
Science and Technology for Children (STC)	in development	X	*
Science Curriculum Improvement Study (SCIIS)	X		
Science for Life and Living (BSCS)	X		
Science Horizons (Silver, Burdett & Ginn)	X		
Search for Solutions			X
Silver Burdett & Ginn Elementary Science	X		
Students and Research			X
Teaching Integrated Math and Science (TIMS)		*	X
Voyage of the Mimi			X
Windows on Science (Optical Data)	X		

Key: X designates primary function
 * designates alternate function

Instructional Emphases

Although the primary focus of the guide is the review of print (or visual) curriculum materials, there is a need to portray the integral relationship of curriculum and instructional emphases which dominate the reviewed materials. On the following page, Table 2 highlights these instructional emphases for each curriculum material reviewed. The table should guide the reader to understand the dominant instructional practices found in the cited material. In addition, the table should help the reader to compare one curriculum with another within the broad categories of comprehensive/stand-alone series, modular programs, and supplementary materials. A definition of the major instructional emphases found in the curriculum materials follows:

Reading based: The primary vehicle for presenting content is through written text.

Inquiry based: Curriculum starts with open-ended questions. Students engage in problem finding as well as solution finding. Various activities such as hands-on investigation, reading, and discussion comprise the program. Inquiry-based curricula do not require student research.

Media Delivered: Uses any non-print delivery system such as DC-ROM, video tapes, video disc to present content.

Student Research: The curriculum pursues a question or problem based on a formal research procedure such as experimental design.

Interdisciplinary: The curriculum connects the vital elements of one discipline with another so that understanding the first discipline illuminates the other(s). For instance, the curriculum would look at patterns, symmetry, systems, etc. in the fields of science, art, music, and mathematics.

Science Tools: Students use the current tools of science such as computers, probes, data bases, and interactive video discs while working on science investigations. Use of technology is an integral part of the curriculum. This category is distinct from "media delivered" which uses video tapes or discs to present content.

Activity based: The program centers around hands-on work for students. However, the hands-on activities may not be inquiry based and center on questions. Nor does it imply the entire scientific process.

Table 2: Curricula Selected for Review

Title	Reading Based	Inquiry Based	Media Delivered	Student Research	Inter-Disciplinary	Science Tools	Activity Based
AIMS							X
BSCS	X	*		*	*	*	
CEPUP		X			*		*
Challenge of the Unknown		*	X		*		*
Discover Science	X						
ESS		X			*		*
FAST		X					*
FOSS		X					*
Focus on Science	X						
GEMS		X		*			*
Insights		X					*
LEGO/Logo		*				X	*
Life/Physical/Earth Science	X						
Prentice-Hall Middle School Life Science	X	*					*
Nat'l Geo. Kids Network		*		*	*	X	*
SAPA		X					
Science for Life and Living	X	*			*		*
Science Horizons	X						
Science & Technology	X						
Science & Technology for Children		X			*		*
SCIIS	*	X			*		*
Search for Solutions	*		X		*		
Silver Burdett & Ginn - Elementary Science	X						
Students & Research				X			
TIMS		*		X	*		*
Voyage of the Mimi			*		X		
Windows on Science			X				

Key: X Primary focus of curricula
 * Element of curriculum but not primary focus

Section II

Comprehensive/Stand-Alone Series

Comprehensive/Stand-alone series are intended for a particular age group or grade level. They are designed to present a student's total science program for a school year and are often adopted by a school system for all science instruction in grades K-6 or 6-8. Generally these curricula are written for and marketed by the major educational publishing houses. Included in this section are reviews of two of the widely used basal textbook series--Discover Science and Science and Technology--and two innovative attempts to bring the basal text into the modern age: Windows on Science and Science for Life and Living.

List of Comprehensive/Stand-Alone Series Reviewed

Biological Science: A Molecular Approach (BSCS Blue Version)

Discover Science

Focus on Science (Merrill)

Foundational Approaches in Science Teaching (FAST)

Life/Physical/Earth Science (Prentice-Hall)

Middle School Life Science (Kendall/Hunt)

Science--A Process Approach (SAPA)

Science for Life and Living (BSCS)

Science and Technology (Harcourt, Brace, Jovanovich)

Science Horizons (Silver, Burdett & Ginn)

SCIIS (Science Curriculum Improvement Study)

Silver Burdett & Ginn Elementary Science

Windows on Science (Optical Data)

Secondary-Introductory biology
Grades 7-8 (Gifted)

Biological Science: A Molecular Approach

BSCS Blue Version, Sixth Edition

Developed by Biological Sciences Curriculum Study, Colorado Springs, CO

Published and Distributed by D.C.Heath and Company, Lexington, MA

1990

OVERVIEW

Description

Biological Science: A Molecular Approach is a laboratory-based, introductory biology course that explores the role of molecular biology and biotechnology in the world. Developed by the Biological Sciences Curriculum Study, a nonprofit corporation established in 1958 to rejuvenate and restructure the tenth-grade biology curriculum, the program focuses on "above average" students. This course, known as "BSCS Blue Version," along with other BSCS secondary curricula have provided a model that is often followed by other high school biology textbooks (McInerney, 1986).

Program components include: student text, teacher's annotated edition, teacher's resource book, student study guide, and a computer test bank. Laboratory investigations which are keyed to each chapter are located in the back of the student text. The investigations include activities such as: demonstrations of laboratory procedures, guided observations, open-ended experiments, case studies of ethical issues, and concept map development.

Major Program Goals

Overall goals of BSCS secondary programs as stated in the Teacher's Annotated Edition are to develop an understanding and appreciation of the following concepts:

- the nature of scientific inquiry. Science is an open-ended, intellectual activity, and what is presently "known" or believed is subject to change at any time.
- the limitations of science and of scientific methods.
- the diversity of life and the interrelations among organisms.
- the biological bases of problems in medicine, public health, agriculture, and conservation.
- the historical development of biological concepts and the relationship of those concepts to the society and technology of each age.
- the beauty and drama of the living world.
- our place in nature. As living organisms, we have much in common with other organisms. We interact with all organisms in the biological system of Earth, and we must share Earth with them.

Research Evidence of Effectiveness

A number of studies have been done to determine effectiveness of the various BSCS programs developed in the 1960s (Special Materials, Yellow, Blue, Green, and Advanced). A quantitative synthesis procedure called "meta-analysis" that analyzes the results of this research was carried out by Shymansky, Kyle, and Alport (1983). Based on this analysis, the authors

conclude that there is a substantial body of literature that indicates that the science curricula of the 1960s were a successful attempt to improve science education. The following high effect sizes for BSCS Blue Version were found:

<u>Outcome Area</u>	<u>Mean Effect Size</u>	<u>Number of Studies</u>
Composite	2.32	N = 6
Achievement	3.94	N = 2
Perceptions	1.75	N = 1
Process Skills	2.45	N = 1
Analytic Skills	0.94	N = 2

(Note: Effect size is defined as the mean difference between the treatment conditions divided by the standard deviation of the control group; a positive effect size indicates that students in the experimental curriculum performed better than the control group. Effect sizes in the range of below .30 are considered low, .30 -.45 modest, .45 -.60 moderate, and .60 and above high.)

Shymansky (1984) states the following conclusions about BSCS programs:

- Students in each of the BSCS programs performed better than students in traditional biology courses across all performance measures.
- Predominantly male classes responded less favorably than mixed gender classes.
- High-IQ, high ability students in all versions of BSCS biology achieved higher scores on measures of learning by a greater margin than did low-IQ and average-IQ BSCS students.
- Students from higher SES groups responded more favorably to BSCS than did lower SES students.
- Teachers with greater experience and more educational background were more successful with BSCS biology.
- Students from schools with over 2,000 pupils made greater gains than those from smaller schools.
- Students in suburban schools outperformed control groups taking a traditional biology course by the greatest margin (89%); urban settings were only slightly less effective, while rural settings showed only a 14% gain for using the materials.

ANALYSIS

General Curricular Features

Curriculum design.

BSCS Blue Version differs from traditional textbooks in that it uses a "narrative of inquiry" rather than a "rhetoric of conclusions." Schwab (1965 cited in Joyce & Wiel, 1986) explains that the "narrative of inquiry" shows the conclusions of science in the framework in which they arise and are tested. It presents the history of major ideas by following the interpretation of data and how it is converted into scientific knowledge. Conversely, the "rhetoric of conclusions" refers to the exposition of science as a series of unqualified, positive statements. It gives the impression that science consists of unalterable, fixed truths, that science is complete, that it fails to show scientists capable of error, and that it fails to show summarizing concepts that are continually revised and replaced.

The student text contains 26 chapters grouped into six units: Unity and Diversity; Structure and Function of Cells; Genetic Continuity; Evolution: Change Through Time; Life Processes: Regulation and Homeostasis; Organisms and Their Environment. "Biological Challenges" integrated into the chapters provide information on technology, research, discoveries, and careers. Sixty-one investigations at the end of the book provide a variety of open-ended experiments and other hands-on activities. Thirty-three appendices provide detailed coverage of such topics as radioisotopes and research in biology, constraints on cell size, the Old Man from La Chapelle-aux-Saints, generating antibody diversity, and aggression. A glossary concludes the text.

Ten themes are woven into the content of the text which emphasizes molecular biology, genetics, and evolution. The ten themes include: evolution, diversity and unity, genetic continuity, organisms and the environment, behavior, structure and function, regulation, science as inquiry, history of biological concepts, science and society. The themes are integrated throughout the text in both content and process applications. For instance, science and technology appears in content discussions of technological innovations, and it is the focus of ethical inquiries that require student decision making.

Classroom implementation.

Biological Science: A Molecular Approach offers a wide range of materials and strategies that can be used to tailor an introductory biology program. In addition to rigorous content and laboratory investigations, various activities promote student learning. Concept maps, for instance, are used in a several ways. First, students learn to construct concept maps in order to organize information and to establish relationships between ideas. Students work on maps individually, in small groups, and then discuss and evaluate their maps. Secondly, detailed concept maps are provided throughout the text as comprehension aids for complex concepts such as cell metabolism. In addition, chapter reviews provide incomplete concept maps in a variety of forms along with suggestions for student mapping.

Other text features include numerous illustrations and diagrams; a variety of application, synthesis and self-evaluation techniques for students; and interdisciplinary extensions. They have opportunities to develop a game or a skit to explain the most important aspects of cellular respiration; to show as a cartoon or a series of cartoons the sequence of events that occur during translation on the ribosomes; to draw a one-scene piece of modern art that depicts the process of meiosis; to propose regulations for local enactment; and to write essays, short stories, and poems.

A variety of supplementary resources are available for teachers and students. The teacher's annotated text contains background information; resources; objectives, strategies and guidelines; and answers to all questions in the student text. A 288-page Teacher's Resource Book includes supplementary topics with advanced content; an extended laboratory program that includes microcomputer-based labs and labs using gel electrophoresis; reprints of recent articles from Science; independent research problems; and blackline masters that provide enlarged visuals from the student text. A study guide for students reinforces content with four to ten pages per chapter with additional problem-solving, application, and analysis exercises. A computer test bank with questions and graphics enables teachers to create tests keyed to specific content and to different levels of student ability.

Technology.

Biological Science: A Molecular Approach thoroughly integrates issues of science, technology, and bioethics with content information and with problem solving investigations. Twelve of the student investigations utilize an optional LEAP microcomputer system for data collection and analysis. Available from Ward's Biology, the LEAP-System includes probes and computer software compatible with either Apple II series or IBM-PC computers. Only the text materials were evaluated for this review.

BSCS Classic Inquiry videotapes (or super-8 mm film loops) available from Media Design Associates reinforce content in the student text. The annotated teacher's edition alerts teachers to the possibilities of using the Classic Inquiry tapes both for traditional viewing and in other ways such as with the sound turned off to elicit inquiry or application of knowledge. In addition to the BSCS videotapes, the teacher's edition provides annotated lists of film resources and software resources that correlate with each chapter of the student text.

Exemplary Science Features

Science content.

The BSCS Blue Version text does an exemplary job of delivering the content necessary to understand modern biology. It takes a unique approach, focusing first on the chemical basis of life, on molecular evolution, and on molecular biology. It then moves on to topics on a more macroscopic scale. Thus, organismic biology and population biology are treated after genetics and molecular biology. The molecular biology and genetics content is delivered understandably and in depth; it forms a strong foundation for understanding the rest of biology. This is a particularly strong approach given the nature of modern biology: the latest, most innovative, and most exciting research in many areas of biology depends on molecular biological ideas and techniques. It may also be highly motivating for a student. The strong connections made between the molecular basis of life and all other aspects of biology make the field seem logical and comprehensible rather than a random collection of essentially unrelated disciplines. It is also a scientifically deep approach: all organisms are related at the molecular level, thanks to their evolutionary history. Thus, the connections made by this textbook's approach directly reflect the real life commonalities between organisms. The unifying themes stressed in the text are integral to its organization and scientifically rich. The readings from Science are particularly valuable for extending science content and making the text material relevant to the real world. Teachers who use this program should have substantial background in science, particularly in biology.

Science process.

The laboratory experiences, while mostly preplanned, are excellent. They deliver important scientific content using appropriate scientific tools; they are well-planned, likely to work, and scientifically significant. They emphasize the development of proper scientific habits of mind. The results are not apparent simply from reading the lab beforehand; and the post-lab questions focus both on elements of experimental design (questions are asked about variables and controls, even if the items in question are not labeled as such) and on the biological implications of the results. It would be particularly important, when using this curriculum, for a teacher to use as many of the labs as possible.

The section "Research Problems in Biology" is a particularly valuable resource. In this section students are presented with just enough information about a research problem and suggested resolution techniques to get students started on an independent project. In general, the research problems are simple enough to be addressed by a single experiment and thus are able to be carried out in a reasonable amount of time. Students must define the problem precisely, create a testable hypothesis, write an experimental protocol, perform the experiment, and analyze the data on their own. These items are not provided in the information. Thus, these problems are extremely open-ended and provide good springboards for creative labwork under the mentorship of the teacher. Such independent projects would be extremely valuable to students, particularly to gifted and science-prone students at least on a twice-a-year basis.

Tailoring for Special Populations

Differentiation for high ability learners.

BSCS Blue Version developers describe the program as appropriate for above-average, highly motivated learners. This review process confirms that description. The biological concepts are addressed in a comprehensive and detailed manner, requiring students to understand phenomena that often cannot be directly observed (historical, theoretical, or microscopic in size) and respond in ways that assume critical thinking skills. The reading level of the text is challenging and the vocabulary is abundant and difficult. Questions that follow each chapter include "Reviewing Ideas," "Using Concepts," and "Synthesis." The last two cannot be answered by merely reading the text. They often require understanding and comparison of complex scientific concepts. For example, one synthesis question asks students "What is the relationship between the Krebs Cycle and the Calvin Cycle?" and "Relate the end product of chemical digestion to the process of photosynthesis and cellular respiration." Laboratory investigations include a number of "Analysis" questions that also require critical thinking. The program organizes content around the ten themes described in the design section of this review. The themes are highlighted by the use of blue rectangles in the margins whenever one of the thematic strands applies to a particular section.

Numerous challenging extension opportunities are included with every chapter. For example:

- Design an imaginary organism that has characteristics that would classify it in one of the five kingdoms. Sketch it or write about it in detail.
- Develop a hypothesis to explain why cyanide is lethal to humans.
- Research information about the growth of cancer cells. Compare their cell cycle to that of normal cells.
- Research and sketch the development of a specific organism. Some possibilities are birds, opossums, kangaroos, platypuses, butterflies, spiders, and sea turtles. What relationship, if any, exists between the environment, the organism's way of life, and the development of the organism?

This text is a rare example of one that does not attempt to reach all students in its presentation. It would be challenging to high ability tenth graders and even more so for such students in a seventh grade life science course. It would also be appropriate for gifted learners. However, it should probably not be used in a heterogenous classroom as the level of complexity and abstraction of the text requires functioning in a formal operations mode. In order to derive the full impact of the program, teachers need to draw from the various resources that are available

such as the full use of the extended laboratory experiences, background readings, information in the appendices, and extension possibilities.

The BSCS Blue Version has been used successfully with gifted junior high age students since 1982 in a three week summer program at the Center for Talent Development at Northwestern University. The College Board Achievement Test in biology was administered as a post-test. In *three weeks*, the junior high age students were able to achieve scores comparable to the level of students four to six years older (VanTassel-Baska and Strykowski, 1986).

Other special populations.

BSCS Blue Version includes topics that make biology attractive to a diverse population. These topics include real life issues, career opportunities, and representations of ethnic, female, and minority role models.

CONCLUSION

Biological Science: A Molecular Approach (BSCS Blue Version) continues its mission of setting the pace for secondary science biology through rigorous inquiry. It integrates ten scientific themes with science laboratory investigations and challenging content that emphasizes molecular biology, genetics, and evolution.

This curriculum is designed as an introductory secondary biology program for "above-average, highly motivated" students. Although it is generally used as a tenth or eleventh grade program, it has been used successfully with junior high students who have been identified as gifted learners.

Biological Science: A Molecular Approach provides a wide range of resources and experiences that offers the flexibility necessary for meeting the needs of high ability learners. For instance, the Teacher's Resource Book includes extended laboratory programs, readings and discussions, and topics for independent laboratory research. In order for the potential of this curriculum to be realized, teachers must take advantage of its comprehensiveness.

REFERENCES

- Joyce, B. & Weil, M. (1986). Models of Teaching. Englewood Cliffs, NJ: Prentice-Hall.
- McInerney, J. D. (1986). Curriculum development at the Biological Sciences Curriculum Study. Educational Leadership, 44, 24-28.
- Shymansky, J.A., Kyle, W.C., and Alport, J.M. (1983). The effects of new science curricula on student performance. Journal of Research in Science Teaching, 20, 387-404.
- Shymansky, J. (1984). BSCS Programs: Just how effective were they? The American Biology Teacher, 46(1), 54-57.
- VanTassel-Baska, J. and Strykowski, B. (1986). An Identification Resource Guide on the Gifted and Talented. Northwestern University. The Center for Talent Development, Evanston, IL.

Curriculum Evaluation Form

Biological Science: A Molecular Approach (BSCS Blue Version)

Phase I Review

<u>Curriculum Design</u>	<table border="1" style="display: inline-table;"><tr><td>3</td><td>2</td><td>1</td></tr></table>	3	2	1	Average Rating
3	2	1			
Reviewer #1	2.68	2.84			
Reviewer #2	3.00	(Scale 1-3)			

<u>Classroom Design</u>	<table border="1" style="display: inline-table;"><tr><td>3</td><td>2</td><td>1</td></tr></table>	3	2	1	Average Rating
3	2	1			
Reviewer #1	2.71	2.74			
Reviewer #2	2.76	(Scale 1-3)			

<u>Technology</u>	<table border="1" style="display: inline-table;"><tr><td>3</td><td>2</td><td>1</td></tr></table>	3	2	1	Average Rating
3	2	1			
Reviewer #1	Not rated	Not Rated			
Reviewer #2	Not Rated				

Phase II Review

<u>Science Content</u>	<table><tr><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr></table>	5	4	3	2	1	Average Rating
5	4	3	2	1			
Reviewer #1	4.67	4.75					
Reviewer #2	4.83	(Scale 1-5)					

<u>Science Process</u>	<table border="1"><tr><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr></table>	5	4	3	2	1	Average Rating
5	4	3	2	1			
Reviewer #1	3.86	3.97					
Reviewer #2	4.07	(Scale 1-5)					

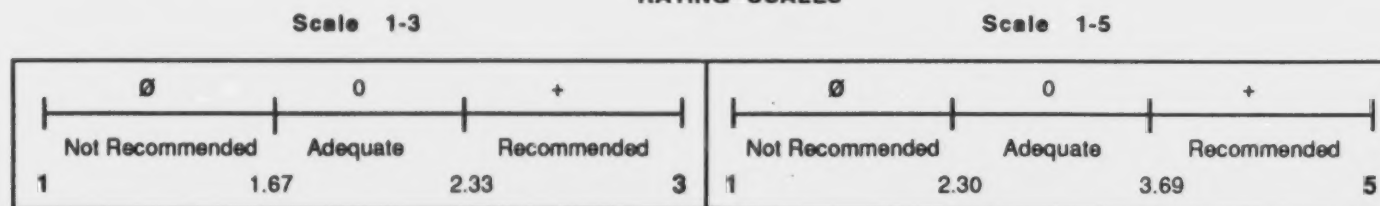
Phase III Review

<u>High Ability Learners</u>	<table><tr><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr></table>	5	4	3	2	1	Average Rating
5	4	3	2	1			
Reviewer #1	4.08	4.04					
Reviewer #3	4.00	(Scale 1-5)					

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Biological Science: A Molecular Approach	2.84 +	2.74 +	Not Rated	4.75 +	3.97 +	4.04 +	A, B

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Scott Foresman Discover Science
Scott, Foresman and Co., 1989
199 East Lake Avenue
Glenview, IL 60025

Grades K-6

OVERVIEW

Description

Scott Foresman Discover Science is a basal textbook program that develops four strands of science (life science, physical science, earth science, and the human body) from kindergarten through grade six. The life science strand includes plants, animals and ecology; physical science includes matter and energy; earth science includes earth, weather and space; the human body strand covers human body systems, as well as health issues.

The basic materials in the series include the traditional student texts along with teachers' editions. Ancillary materials for each grade level in the series include: three blackline master books titled, Teacher's Resource Book, Science Process Skills Book, and Test Book; a student workbook and teachers' manual; posters; a Science Discovery Center and Center book; equipment kits; a videotape; and computer software.

Major Program Goals

No overall goals are stated for the Discover Science series. Major concepts and objectives are listed for each lesson with a content scope and sequence chart providing the series framework. For instance, the major concept for the sixth grade second lesson in chapter seven, "Investigating Compounds" reads, "A chemical reaction is represented by a balanced chemical equation." The following objectives are then listed for the lesson:

- List four types of chemical reactions.
- Interpret a chemical equation.
- Explain how balanced equations apply to Law of Conservation of Mass.

Research Evidence of Effectiveness

No research evidence of effectiveness is available for Discover Science. Rather, the publishers conducted field testing or market research during the developmental stages of the series. Market research includes surveying the literature of educational research and educational reform movements to determine current trends. In addition, teachers are polled and students interviewed in order to improve the product. Summaries of the field testing or market research are then made available to textbook adoption committees in various forms such as "Learner Verification" reports.

ANALYSIS

General Curricular Issues

Curriculum design.

The content of Discover Science is presented in small increments that translate from lesson goal to text presentation and then to test question. For instance, in the fifth grade unit on earth science, each lesson goal begins, "You will learn..." then concludes with content information such as "how physical weathering changes the earth's crust" and "how chemical weathering changes the earth's crust." After four pages of explanatory, extensively-illustrated text, review questions ask, "What are the three causes of physical weathering?" and "How is chemical weathering different from physical weathering?"

The Discover Science series emphasizes reading comprehension in several ways. The Dale-Chall or the Spache Readability Formula is applied to each lesson so that vocabulary and sentence length match the specified grade level. Each heavily-illustrated chapter consists of short lessons featuring main ideas and supporting details. Vocabulary words appear in boldface type within the text and are defined in the margins. The lesson review questions then provide a check of student comprehension. In addition, the teachers' manual pays particular attention to reading comprehension with a section of detailed instructional reading strategies and suggestions for using them at the beginning of each lesson. Although this format is intended to improve student achievement, it results in a simplistic treatment of content and encourages the teaching of science as reading.

Classroom implementation.

Discover Science is a text-centered curriculum. Although a variety of activities and strategies are suggested in the teachers' manual, reading and discussion form the basis of each lesson. The majority of the lesson objectives begin with words such as "describe," "explain," "discuss," "give examples," "define," and "list." Students read the text and teachers check their comprehension.

Chapter tests and unit tests in student texts plus similar tests in the blackline-master books are the only assessment procedures offered by the Discover Science series. The teacher's manual suggests using a cooperative learning strategy to help students prepare for the tests. Students then take the multiple-choice, short-answer, and essay-question tests individually. Teams earn rewards based on average team scores, thus encouraging the use of the test within cooperative learning groups.

Technology.

The Discover Science series does not integrate technology into the curriculum. Supplementary audio-visual resources and computer software are listed at the beginning of each unit.

Exemplary Science Features

Science content.

Although it is standard practice for basal texts to "spiral" the curriculum and to provide deliberate opportunity to re-teach important concepts, the content of the Discover Science series is excessively repetitive. This series emphasizes rote learning and remediation. As an example, the chapter on electrical energy at the sixth grade covers much of the same material that was introduced in the electricity and magnetism chapter in the fourth grade. Similarities of the two chapters include: demonstrating electrical charge with a balloon and a piece of wool cloth, information about magnets, magnetic fields, and electromagnets. In addition, the photographs and illustrations are similar. The fourth and sixth grade chapters on electricity could be collapsed with ease into one unit.

By covering too many big topics in a shallow way rather than fewer topics in depth, Discover Science treats significant science content in a superficial manner. Emphasis on vocabulary rather than on real explanation of the content leads to confusion. For instance, vacuoles are found in plant cells, but not, as the sixth-grade student text implies, in animal cells. Chromosomes are not "made" of DNA as the text states--they are highly complex and contain DNA, RNA and many different proteins. Nor do chromosomes alone do not control the rate of cell growth and the timing of cell reproduction. Another example of misstatement or vague explanation is the definition of plant cell walls as nonliving and plant cell membranes as living. Cell membranes, by themselves, are not alive; both are parts of living organisms. Such inaccuracies decrease the value of covering complex topics.

Science process.

Although the teacher's manual lists science process skills, thinking skills, and problem solving skills for each chapter, the text-centered nature of this curriculum may preclude the actual practice of skills in the classroom. The student activities which are essential for true understanding and learning become peripheral. With this series, it is possible for teachers to assign reading the text and omit the activities.

The majority of the suggested science experiences are verification exercises or observations rather than open-ended investigation. The motivating activity at the beginning of each lesson, in particular, is generally a demonstration rather than hands-on activity which would elicit questions from students and further seeking of answers. Students spend their time observing, not inquiring.

Tailoring for Special Populations

Differentiation for high ability learners.

The Discover Science series targets typical learners in a format that is teacher-directed and text-centered. The low level nature of this science series with its built in remediation makes it inappropriate for high ability learners. In order to use this series, teachers would be forced to create new science investigations and to generate their own adaptations to successfully meet the needs of high ability students.

The extension activities for gifted learners presented in the teacher's manual also are disappointing. Some activities suggest that "high-potential students" write questions for other students and present them in decorated file folders for mini-centers. Other activities present plans in cookbook fashion for students to create games or models. Overall, the series lacks the elements of an exemplary science curriculum as well as necessary ingredients that satisfy the learning needs of high ability learners such as problem finding and the incentive to develop high quality products.

Other special populations.

The pre-teaching suggestions at the beginning of each chapter in the teacher's manual lists suggestions for visually impaired and hearing impaired students. The suggestions for "special education" which are included in each lesson plan provide one idea to encompass the disparate needs of students who are mentally retarded and those with learning disabilities. For instance, the section labeled "Special Education" in the fourth grade lesson "What is Matter?" suggests having students with learning disabilities place water in the school cafeteria freezer in order to observe the change from a liquid to a solid.

The photographs in the student texts show both boys and girls conducting experiments. Likewise, the anecdotal pages called "Science and Technology" and "Science and People" offer glimpses of working scientists that include men and women of various ethnic groups. In addition, the cooperative learning suggestions may encourage girls and minority students to actively participate in science.

CONCLUSION

Scott Foresman Discover Science program is a reading-based science program that attempts to meet the composite needs of the nation's elementary school teachers who have little time and resources to teach science. The broad overview of topics that it covers results in an oversimplified presentation of science that is confusing and often inaccurate.

Although many hands-on activities and projects are suggested throughout the series, scientific inquiry is not an integral part of the program. The suggested activities demonstrate content in the self-contained text.

The low level content and repetitious nature of Discover Science makes it inappropriate for high ability learners. The series offers neither sufficient science content nor process to challenge their abilities.

Curriculum Evaluation Form

Discover Science (SF)

Phase I Review

Curriculum Design

3	2	1
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Average Rating

Reviewer #1

2.03

2.03
(Scale 1-3)

Classroom Design

3	2	1
---	---	---

Average Rating

Reviewer #1

1.86

1.86
(Scale 1-3)

Technology

3	2	1
---	---	---

Average Rating

Reviewer #1

NA

NA

Phase II Review

Science Content

5	4	3	2	1
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Average Rating

Reviewer #1

2.22

2.78

Reviewer #2

3.33

(Scale 1-5)

Science Process

5	4	3	2	1
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Average Rating

Reviewer #1

1.50

1.46

Reviewer #2

1.41

(Scale 1-5)

Phase III Review

High Ability Learners

5	4	3	2	1
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Average Rating

Reviewer #1

1.50

1.83

Reviewer #3

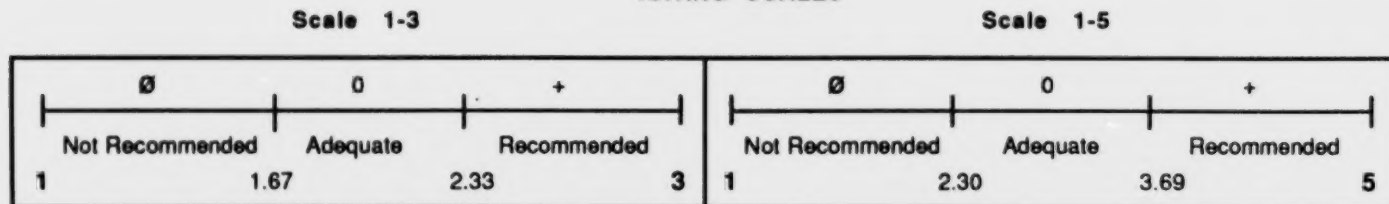
2.16

(Scale 1-5)

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Discover Science (SF)	2.03	1.86	NA	2.78	1.46	1.83	
	0	0		0	0	0	

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Focus on Life Science

Grades 7-9

Focus on Physical ScienceFocus on Earth Science

Charles E. Merrill Publishing Company

P.O. Box 508

Columbus, OH 43216

1989

OVERVIEW

Description

Each of the three Focus on Science texts is a year long curriculum covering topics in its respective area of science. The eight units in Focus on Life Science are: Life Science Foundations; Simplest Organisms; Plants; Animals; Heredity and Evolution; Human Life; Staying Healthy; and The Environment. Focus on Physical Science covers these seven units: Physical Science Fundamentals; Force and Energy; The Nature of Matter; Patterns of Matter; Interactions of Matter; Waves, Light, and Sound; and Energy Resources. The Focus on Earth Science units include: Earth Science Foundations; Earth's Air and Water; Surface Processes; Rocks and Minerals; Internal Processes; Earth's History; and Earth's Resources.

In addition to the student textbook, the following materials are available: an annotated teacher's edition of the text, a teacher's resource book, a review and reinforcement guide, a laboratory manual, software for chapter review and generating tests, transparencies, and skillcards for reinforcement and enrichment.

Major Program Goals

Two broad goals of the series are:

- 1) to help students recognize and appreciate applications of science to every day living, and
- 2) to develop and reinforce thinking and manipulative skills.

Performance objectives for each chapter are keyed to the following broad goals of science education:

- 1) **Attitudes:** to develop students' attitudes of curiosity and involvement with occurrences in their environment; to develop an appreciation for the contributions of science; and to recognize the value of solving problems in a scientific manner.
- 2) **Processes:** to develop those intellectual processes of inquiry by which scientific problems and occurrences are explained, predicted, and/or controlled.
- 3) **Knowledge:** to develop knowledge of facts, terminology, concepts, generalizations, and principles that help students confront and interpret occurrences in their environment.
- 4) **Skills:** to develop students' abilities to handle, construct, and manipulate materials and equipment in a productive and safe manner; and to develop the ability to measure, organize, and communicate scientific information.

Research Evidence of Effectiveness

No research evidence is available for effectiveness of the Focus on Science series. Rather, the publishers conducted field testing or market research prior to the publication of the series. Market research includes surveying the literature of educational research and educational reform movements to determine current trends. In addition, teachers are polled and students interviewed in order to improve the product. Summaries of the field testing or market research are then made available to textbook adoption committees in various forms such as "Learner Verification" reports. The Merrill Publishing Company conducted a Learner Verification for the Focus on Science series during the 1986-87 school year. Students of average ability and a wide range of socio-economic backgrounds used the 1987 editions of the three texts. 105 students used the Life Science book, 107 used Physical Science, and 90 used Earth Science. Conclusions from the process state that:

- a) Students overlooked some of the key goals for major divisions within the book.
- b) Review questions at the end of major sections lacked variety and did not challenge higher level thinking.
- c) Students had some confusion in understanding directions with short form lab activities.

The following changes were made in the 1988 edition in response to these findings:

- a) Goals were highlighted for each of the major divisions of the text.
- b) Review questions at the end of the major sections were changed to include higher level thinking questions.
- c) All lab activities were changed to a long form to clarify intent and stress lab safety.

The publishers are to be commended for this effort. However, this does not constitute a study of the effectiveness of the program in terms of student learning.

ANALYSIS

General Curricular Features

Curriculum design.

The Focus on Science series is designed to deliver comprehensive coverage of content in the areas of life, earth, and physical science. Many topics are included within the presentation of each concept. The series is aimed at average learners but tries to reach a wider range through a variety of resources. Hands-on activities complement the reading/discussion components of the text. They are presented through "Skill" and "Investigation" sections in each chapter and can be supplemented by activities from the lab manual and the teacher's resource book. "Skill" activities are designed to introduce or reinforce thinking or lab skills. Each chapter has a problem solving activity that is designed to address the universal question from students, "Why do we have to learn this?" For example, in Focus on Earth Science a problem describes a boy who rides his bike to the filling station to put air in his bicycle tires, but when he arrives he finds them to be firmer than when he left home. Students are asked to find out why this is so.

Another problem from Physical Science asks why the driver of a small car feels pulled toward a moving van that it is passing on a highway.

Classroom implementation.

The teacher's edition includes a planning guide for each chapter with activities coded for different levels of challenge. They range from word puzzles to designing experiments. Though most of the activities are teacher or text directed, some that require original thought and design can be found in the teacher's resource book in the "Enrichment" or "Application and Inquiry" sections; they can be used independently or in small groups. Ideas for projects appear at the end of each chapter. Decision making, open inquiry, and divergent products are not strong in this series; most lab and investigation procedures are spelled out for students with correct answers to follow-up questions written out in the teacher's key.

In the teacher's edition, the introductory material for every chapter suggests an interdisciplinary connection between the science topic presented and another discipline. For example, in a Physical Science chapter on chemicals it is suggested that the production of sulphuric acid is an indicator of economic growth; students are asked to research the uses of sulphuric acid to see why this may be true. However, since these interdisciplinary suggestions appear only in the teacher's margins, students will not make these connections unless they are introduced by the teacher.

Assessment is done primarily through traditional tests. Those that accompany the series are objective items with some short essay questions. The teacher's resource book suggests that teachers should also use an observational check list and student notebooks for assessment purposes. This is a good suggestion but it is embedded within many pages of fine print and may go unnoticed.

The Merrill series gives strong support for teachers in the form of handouts and optional activities. Additional student reading material is listed at the end of each chapter with reading levels noted in the teacher's edition. The Science and Society sections list current references along with these articles. Additional books, magazines, software, and films are listed in each chapter as teacher resources.

Teaching strategies tend to be unimaginative but a creative teacher can break out of the read/discuss/lab mode that commonly dominates basal text instruction. If a teacher considers the text to be a resource and spends class time on hands-on and creative activities, instruction will be enhanced.

Technology.

Two pieces of computer software are marketed by Merrill for use with this series. One is an electronic method of reviewing facts; it refers students to the appropriate page in the text if a wrong answer is selected. The other is simply a media presentation for generating tests. Both have limited value as they are duplicating functions that are already provided elsewhere.

Exemplary Science Features

Science content.

The Focus on Science series has a strong content base in both science and technology. It is understandable to read, incorporates practical applications of theory, and includes mathematical support where appropriate (e.g., formulae, balancing chemical equations, graphing). Up-to-date applications and issues are presented in the Science and Technology section at the end of each unit. These sections discuss topics such as radon contamination, organ transplants, and the problem of plastics disposal. Students are pushed to "develop a viewpoint" through a set of stimulating questions and suggestions for finding more information.

Science process.

The scientific process aspect of the of these texts is not strong. Students are led through the labs and activities step by step. However, they still serve a purpose in reinforcing scientific concepts and giving students a chance to participate actively. For example, the student who observes the stages of metamorphosis in meal worms firsthand is more likely to understand and remember that experience than if s/he had only read about it in the text. Few opportunities are included for students to think and act like scientists; their role is more like that of a lab assistant who is told how to carry out each detail of a procedure.

The career education aspect of these texts is very positive. Numerous examples of jobs and professions are included. They range from beekeeper to genetic counselor, with a description of the educational requirements of each job. Mini-biographies of scientists are also included. However, the series does not promote connections between students and real people such as scientists, community resources, or mentors.

Tailoring for Special Populations

Differentiation for high ability learners.

The Focus on Science series is aimed at average ability students but attempts to reach others by adaptation and activity choice. Higher level thinking skills are not the norm but are required in some of the activities. They are most likely to be found in the following features of the program: Problem Solving (one per chapter), Enrichment pages in the resource book, Application and Inquiry pages in the resource book, and Science and Society. Extension readings listed in the chapter review are keyed for ability level so they can be selected appropriately. Among process skills, interpreting and observing are the most common while hypothesizing and comparing/contrasting are only used occasionally.

High ability students need to be entrusted with the task of responding to significant problems or questions in creative, open-ended ways. Only a few examples are included in this series. One is found in the Science and Society section of the Physical Science text; after a discussion of cogenerators as efficient heat and electricity producers, an optional suggestion is given in the teacher's edition for small cooperative groups of students to design and perhaps build a model of an energy efficient house for a remote area where there is no electricity. This example and most other opportunities for creative and high level thinking skills are found outside of the

main text or in the margins of the teacher's edition. When time or energy is short, these may go unnoticed and untouched. It is imperative that teachers seek these out and give them priority for high ability students.

A table in the teacher's guide suggests teaching strategies for special groups of students. However, they are offered as supplementary advice, unrelated to the specifics of this curriculum. Tips for the gifted include: students taking selected subjects earlier, students expressing themselves in art forms, making public services available to students (materials, programs, expertise), asking "what if" questions to develop high level thinking skills, and emphasizing concepts, theories, ideas relationships, and generalizations. These are admirable but will not by themselves guarantee an adequate experience for high ability learners without appropriate curriculum activities.

Other special populations.

Many female and minority scientists and career role modes are portrayed in the career and biographical sketches that are included in each chapter. General suggestions for teaching learning disabled, physically disabled, or behaviorally disabled students are mentioned in the introduction to the teacher's edition.

CONCLUSION

The Focus on Science series offers comprehensive content in each of three areas of science: life, physical and earth. Information about current advancements in applied technology is also incorporated. The series would strongly support a lecture/discussion style classroom but it does not promote meaningful scientific process experiences. While it offers opportunities to observe scientific phenomena and verify results, it lacks emphasis on inquiry-based activities. Modeling of behavior and thinking processes of scientists is missing; these are essential in a program for high ability learners. Used as a resource, this series could supply valuable content, but as a stand-alone program it is not adequate for high ability learners.

Curriculum Evaluation Form

Focus on Science (Merrill)

Phase I Review

Curriculum Design

3	2	1
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Average Rating

Reviewer #1

2.17

2.21

Reviewer #2

2.25

(Scale 1-3)

Classroom Design

3	2	1
---	---	---

Average Rating

Reviewer #1

2.22

2.36

Reviewer #2

2.50

(Scale 1-3)

Technology

3	2	1
---	---	---

Average Rating

Reviewer #1

NA

NA

Reviewer #2

NA

Phase II Review

Science Content

5	4	3	2	1
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Average Rating

Reviewer #1

4.33

4.46

Reviewer #2

4.58

(Scale 1-5)

Science Process

5	4	3	2	1
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Average Rating

Reviewer #1

2.00

2.00

Reviewer #2

2.00

(Scale 1-5)

Phase III Review

High Ability Learners

5	4	3	2	1
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Average Rating

Reviewer #1

3.00

3.21

Reviewer #3

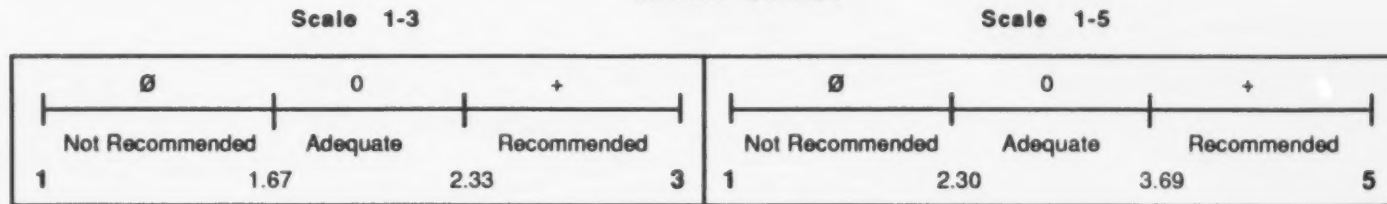
3.42

(Scale 1-5)

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Focus on Science (Merrill)	2.21 O	2.36 +	NA	4.46 +	2.0 Ø	3.21 O	

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Foundational Approaches in Science Teaching (FAST)
Curriculum Research & Development Group
College of Education
University of Hawaii
1776 University Avenue
Honolulu, HI 96822

Grades 6-9

OVERVIEW

Description

Foundational Approaches in Science Teaching (FAST) is an inquiry-based program that centers on laboratory and field work. Designed to encompass three or four years, the content and skills of the program build from one year to the next. Fast 1, "The Local Environment," is recommended as a two-year program for grades six and seven; or as a one year program for grade seven. Fast 2, "Flow of Matter and Energy in the Biosphere," is recommended for grade eight; Fast 3, "Change Over Time," for grade nine. However, the program can be used through twelfth grade depending on local needs and student ability.

As a "foundations" of a science program, the curriculum seeks to impart an understanding of the structure of science as a discipline. To accomplish this, FAST is organized into three strands of physical science, ecology, and relational study. Chemistry and physics concepts are studied independently in the physical science strand. Biology and earth science content is then integrated through a study of major environmental issues in the ecology strand. Finally, the philosophy and history of science form the content of the relational strand which considers science as one of many factors that must be used in societal decision making.

As a National Diffusion Network (NDN) program, FAST materials are available only upon completion of a ten-day Teacher Training Institute. Teacher materials include an instructional guide which provides an overview of the program, a three-ring binder teacher's guide for each level, and an evaluation guide for each level. Student materials for each level include a student book, a student record book, and reference booklets.

Only the FAST 1, "The Local Environment," materials were evaluated for this review.

Major Program Goals

The FAST Instructional Guide states:

The goal of FAST is the development of a scientifically literate student who has (1) the background necessary for understanding the environmental concerns arising in our technological society, and (2) the foundational tools for further study in the sciences. The specific objectives of FAST are to increase student:

1. Capability to perform basic laboratory skills.
2. Capability to use the symbolic tools of science.
3. Knowledge of concepts that are foundational to modern science.

4. Capability to engage in scientific inquiry.
5. Understanding of the sequential nature of the history and development of science.
6. Understanding of the relationships among disciplines of science.
7. Knowledge of the nature of science.
8. Capability to apply a knowledge of science to other areas of endeavor.
9. Understanding of the relationships among science, technology, and society.
10. Capability to use scientific knowledge for decision making.
11. Internalization of the values, attitudes, and traits necessary for successful endeavor in science.

Research Evidence of Effectiveness

FAST developers report that the collection of student impact data has been more difficult than had been assumed in the original dissemination plan. Although adopters sign an agreement that they will conduct student evaluation using the project-designated instruments, follow-through is often lacking. Rather, districts administer their own tests which makes comparison difficult. However, data submitted to NDN in 1978 indicate that students of all ability levels using the FAST program significantly outperformed students using other science programs ($p < .05$) on an in-grade standardized test of science knowledge; the Comprehensive Test of Basic Skills (CTBS).

ANALYSIS

General Curricular Features

Curriculum design.

The title, Foundational Approaches in Science Teaching (FAST), emerges from the basic assumptions of the program which are based on the work of Arthur R. King and John A. Brownell (1966). In brief, the assumptions state:

- (1) The primary purpose of education is the development of each student's intellectual capacities.
- (2) Understanding the structures of the disciplines is essential to an understanding of society's past, present, and future.
- (3) The structure of the disciplines (the knowledge produced by them, and their ways of generating new knowledge) is uniquely suited for instruction.

Each FAST level is organized into the three strands of physical science, ecology, and relational study. The first strand, physical science, provides the foundations of science. The ecology strands provides additional content in the biological and earth sciences within the context of

environmental issues. The relational strand then considers the interrelationships between the sciences, technology, and society as well as confronting the problems and decisions necessary in using scientific knowledge. The scope and sequence of FAST is shown in the charts below.

FAST 1 The Local Environment

Physical Science	Ecology	Relational Study
Introduction to the Properties of Matter	Plant Growth	Air Pollution and/or Water Resource Management
Change in State	Physical Environment	
Temperature and Heat	Animal Care	
	Field Ecology	

FAST 2 Flow of Matter and Energy in the Biosphere

Physical Science	Ecology	Relational Study
Light and Heat	Primary Production	World Food Production
Evidences for an Atomic Theory	Ecological Systems	
A Model of Matter	Productivity of Ecosystems	

FAST 3 Change Over Time

Physical Science	Ecology	Relational Study
Force, Work and Energy	Changing Earth	Man in the Environment
Magnitudes of Change	Life	
Changing Universe	Continental Drift	
	Changing Ecosystems	

The FAST curriculum accommodates the developmental characteristics of young adolescents in several ways. First, it builds on their capacity for abstract thinking. Secondly, it relates science to their lives through a study of community and world issues. Third, it promotes problem solving, positive attitudes toward science, and the value of self-directed learning.

Classroom implementation.

In the FAST program, the teacher acts as a coach and facilitator of student research. In addition to overseeing the laboratory, teachers facilitate student research by grouping the students in various arrangements and by organizing discussion. FAST recommends a large group or whole class arrangement for conveying information and establishing procedures, groups of 10-12 students for discussing controversial issues, small groups of four to six students for problem solving, and teams of two or four for laboratory investigations. The FAST Instruction Guide provides two models for framing discussion questions, and the teacher's guide includes examples of specific questions.

A FAST student book provides background information, laboratory problems, and procedural information. However, the student notebook or log becomes the student text and is the central information piece of the FAST program. For each lab investigation, students write the problem, draw a flow diagram of the procedures to be undertaken, and keep notes of observations, hypotheses, conclusions, summary questions, and vocabulary. The students compile data tables and graph their results.

An evaluation guide for each level of the FAST program provides both formal and informal instruments for assessing student progress. A concept inventory which serves as a pretest and a posttest asks students to rate their level of understanding on all the concepts covered during the year. Checklists are provided for teachers to record observations of concept and skill mastery. Finally, formal tests that include hand-on laboratory assignments and written questions are provided for each unit.

Technology.

The FAST program requires laboratory facilities that include heat sources, running water, and lab bench space for students. Triple-beam, Centogram, or Dial-a-Gram balances are also needed. Supplies for the program are standard catalog items. The program does not utilize computer technology such as word processing, databases, or probes as a part of student investigations.

Exemplary Science Features.

Science content.

In FAST 1, the emphasis is on the use of the scientific process by the learner to develop scientific content. A relatively small number of content areas are covered in great depth over a long period of time. Most of the curriculum focuses on such fundamental physical science concepts as buoyancy and density; there is also a life science section which focuses on pollution and some rather narrow aspects of ecology. In the FAST curriculum, there is not much reading material available; rather, the children are expected to develop an understanding of the

scientific concepts covered by the curriculum through extensive experimentation. Some supplementary pamphlets are provided as additional source of information. The pollution pamphlet, prepared in 1980, looked dated; an updated reference list for students would be useful. Because of the emphasis on student development of content through experiment, little effort is made to place the content developed into a broader context by linkage to the underlying scientific theories. A few rather narrow areas are covered in depth (seed scarification, for example), but the larger concepts that they are supposed to illustrate (ecology, for example) are not really explored. There is a similar lack of focus in interdisciplinary connections and on the societal implications of science.

Science process.

Although the scientific content available for study in the FAST 1 curriculum is somewhat narrow, the scientific process aspects of the curriculum are exemplary. The laboratory work is not only integral to the curriculum, it is the curriculum. Students work in groups or with the teacher as a mentor to solve challenging, open-ended scientific problems; they build and test their own hypotheses, learn to handle data appropriately, learn to question assumptions and try diverse ways of looking at a scientific problem, and use technology appropriately. The only part of the scientific process that is lacking in this curriculum is the part in which a scientist uses resources outside the laboratory to learn about the theoretical and experimental background of his experimental problem and to establish the context in which it is important; opportunities to do this could be provided by the teacher in the form of newspaper articles relevant to the scientific concept under study, examples of its real-life applications, and so on. The depth of coverage of individual FAST topics would be complemented by such reading materials, and yet the FAST emphasis on student development of the content would not be compromised. For example, a newspaper article discussing the reforestation of Yellowstone after the extensive fires that occurred a few years ago would pique the interest of students studying seed scarification and help them to understand its relevance to the topic of ecology: some seeds actually depend on fire for germination!

Tailoring for Special Populations

Differentiation for high ability learners.

Although FAST 1 offers flexible pacing and can be accomplished in one year rather than two years, the curriculum does not provide sufficient content to challenge high ability learners. For high ability learners, the teacher would need to add content with outside resources. Also, the interdisciplinary connections in the ecology and relational study strand would need to be strengthened.

The program sets high standards for all students especially when it comes time to present their work as oral and written reports. This feature of the program is particularly salient for high ability learners. For instance, students are given guidelines for presenting reports according to American Institute of Biological Sciences format. Peer review is part of the reporting process, and criteria for evaluating reports are provided. Students are urged to revise and to consider their work as documents for the class reference file with personal reputations at stake, not as free-style essays to be handed in for a grade. A brief note in the teacher's manual points out that students will have a range of reporting abilities and that advanced students may eventually

handle both the presentation and the critique session. However, teachers will need to work with students to set standards and expectations based on their ability.

Other special populations.

Teachers interviewed about the value of the FAST program (Gore & Pogrow, 1991) reported that FAST enabled disadvantaged youth to perform well in the science classroom and on science tests. Teachers credited the excitement of the activities for involving the students, and they felt it contributed to the students' self esteem. One teacher in Rochester, New York reported that FAST students from lower socioeconomic backgrounds all passed the state competency test in science one year and that all but five passed the test the following year.

Sears (1990) points out that the FAST program is gender-neutral in that it is free of bias. She then discusses subtle biases such as teacher interaction that recognizes boys and ignores girls, thus victimizing the girls. Sears concludes that the discussion and group process training that FAST teachers receive should enable them to recognize such subtle biases and to use the program components to rectify classroom inequities between girls and boys.

CONCLUSION

The FAST program offers a laboratory-based curriculum that is especially designed for middle school students. The curriculum is particularly strong in science process. In addition, the curriculum includes physical science, ecology, and relational study strands that attempt to integrate fundamental science concepts with societal issues.

The high student involvement that the program provides through investigations, discussion, and group work makes it particularly successful with students of low economic status and girls who might otherwise avoid science. Although the program lacks the advanced content necessary to challenge high ability learners sufficiently, it offers opportunities to develop high quality, substantial products through oral and written reports.

REFERENCES

- Gore, K. & Pogrow, S. (1991). Science. Middle School Curriculum Review Series. Issue #2.
- King, A. R., & Brownell, J. A. (1966). Curriculum and the Disciplines of Knowledge. NY: J. Wiley.
- Sears, C. (1990). Equality for males and females in science. Science Education, 9, 19-20.

Curriculum Evaluation FormFoundations in Science Teaching (FAST)Phase I ReviewCurriculum Design

3	2	1
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Average Rating

Reviewer #1

2.94

2.76

Reviewer #2

2.57

(Scale 1-3)

Classroom Design

3	2	1
---	---	---

Average Rating

Reviewer #1

2.75

2.63

Reviewer #2

2.51

(Scale 1-3)

Technology

3	2	1
---	---	---

Average Rating

Reviewer #1

NA

NA

Reviewer #2

NA

Phase II ReviewScience Content

5	4	3	2	1
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Average Rating

Reviewer #1

3.83

3.25

Reviewer #2

2.67

(Scale 1-5)

Science Process

5	4	3	2	1
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Average Rating

Reviewer #1

3.93

3.93

Reviewer #2

3.93

(Scale 1-5)

Phase III ReviewHigh Ability Learners

5	4	3	2	1
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Average Rating

Reviewer #1

3.17

3.46

Reviewer #3

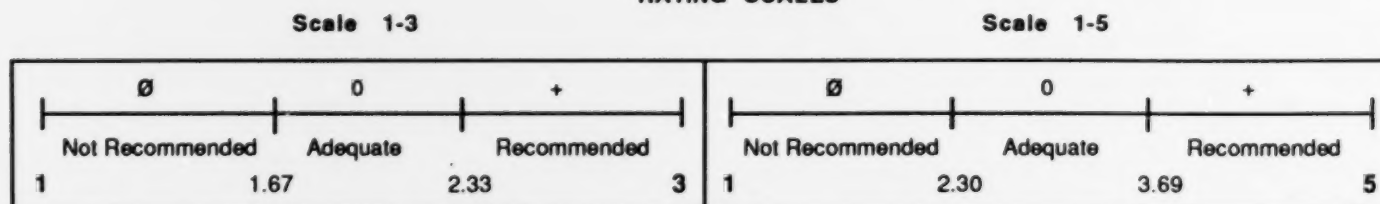
3.75

(Scale 1-5)

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Foundational Approaches in Science Teaching	2.76 +	2.63 +	NA	3.25 O	3.93 +	3.46 O	

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Prentice-Hall Life Science
Prentice-Hall Physical Science
Prentice-Hall Earth Science
 Prentice-Hall, Inc.
 Englewood Cliffs, NJ 07632
 1988

Grades 7-9

OVERVIEW

Description

Each of the Prentice-Hall curricula, Life Science, Physical Science, and Earth Science, is a year long program covering its relevant area of science. Life Science contains 25 chapters in seven units: The Character of Living Things; Simple Organisms; Plants, Animals; Human Biology; Heredity and Adaptation; and Ecology. Physical Science covers 28 chapters in eight units: Diversity of Matter; Patterns in Matter; Interactions in Matter; Motion, Forces, and Energy; Heat Energy; Electricity and Magnetism; and Waves. Earth Science presents astronomy, geology, meteorology, and oceanography in 23 chapters and seven units.

Instructional materials that are available beyond the student text for each curriculum include a teacher's annotated edition of the text, a teacher's resource book (in ring binder format), a laboratory manual, critical thinking skills transparencies, a computer test bank, and computer software.

Major Program Goals

Prentice-Hall Life Science, Physical Science, and Earth Science share the following performance objectives:

- 1) Students will increase their overall scientific literacy.
- 2) Students will gain an understanding of the basic facts and concepts of science and apply these facts and concepts to their everyday life.
- 3) Students will develop critical thinking, problem-solving, and investigative skills that are applicable in other subject areas as well.
- 4) Students will learn to recognize and apply the scientific method of problem-solving.
- 5) Students will learn to respect and practice appropriate safety skills in the laboratory environment.
- 6) Students will recognize the importance of scientific developments -- yesterday, today, and tomorrow.
- 7) Students will develop an appreciation of science and their environment.

Research Evidence of Effectiveness

No research evidence is available for the effectiveness of Prentice-Hall Life Science, Physical Science, and Earth Science. Rather, the publishers conducted field testing or market research during the developmental stages of the series. Market research includes surveying the literature of educational research and educational reform movements to determine current trends. In addition, teachers are polled and students are interviewed in order to improve the product. Summaries of the field testing or market research are then made available to textbook adoption committees in various forms such as "Learner Verification" reports.

ANALYSIS

General Curricular Features

Curriculum design.

Each of the three Prentice-Hall curricula includes comprehensive coverage of life, physical, and earth science. Each program is designed to introduce students to facts, skills, and concepts with up-to-date coverage of material. Emphasis is placed on science in everyday life and the value of science and technology in our world.

Each curriculum contains a skills strand that is identified in a scope and sequence chart in the teacher's edition of the text. It concentrates on mastery of manipulative, critical thinking, and problem solving skills. No other scope and sequence for content is given. Units may be taught in any order, but it is suggested that Chapter One in each text be taught first as it introduces the scientific method, the metric system, safety, and various branches of life, physical, or earth science.

Each of these curricula reflects a textbook reading level that is more challenging than students usually encounter before junior high school. As an aid to reading, a "key idea" sentence is highlighted in each section. A large number of vocabulary words are introduced. To balance the printed text, vivid photos, illustrations, graphs, tables, and charts appear throughout the chapters.

The teacher's edition suggests that the text should be balanced with investigative material. "Sharpen Your Skills" activities and full period investigations are included in every chapter. Their use is recommended but is not required to meet the objectives that are assessed.

Classroom implementation.

Most of the activities in the Prentice-Hall curricula are directed by the teacher, the lab manual, or the text. A teacher demonstration is suggested to introduce each chapter. Activities that are carried out by students are presented in two main formats. The first are laboratory investigations that appear on a full page just before each chapter summary. A separate manual contains 50-65 more investigations. Even though these tend to be demonstration or verification activities, they are worthwhile, hands-on experiences that enhance learning.

The second kind of student activity is suggested by way of a set of "Sharpen Your Skills" activities that are suggested in the margins of the student text. There are five types: hands-on, computational, library research, reading comprehension/vocabulary, and field activity. Worksheets are included in the resource book to accompany many of these. They are labeled as remedial, average, and enriched. Two such activities are suggested in the Life Science section on worms. In the one labeled remedial, students observe earthworms and record their observations; the enriched activity asks students to look up the fluke worm in the library and diagram its life cycle. The enriched activities often assume sophistication in math skills or require library research.

Some interdisciplinary connections are indicated in the teacher's edition through marginal notes

called "Tie-Ins" that relate science to areas such as history, government, and art. Reading, writing, and math are integrated with basic activities. The teacher's resource book includes a worthwhile, interdisciplinary section that is designed to promote specific skills for reading science materials. "Science Gazette" articles in the textbook serve as the content basis for these lessons.

The teacher's resource book contains a detailed lesson plan that organizes the readings, activities, vocabulary, and homework assignments for each lesson. Instructional strategies do not vary substantially from lesson to lesson. The text suggests that students can be grouped together for investigations; however, the purpose appears to be more for logistics of classroom management than for problem resolution or discussion purposes.

Assessment for these three curricula is provided mainly through tests that include recall items as well as two essay type questions. A lab skills assessment chart is included in Physical Science and Earth Science in the teacher's manual for use in observational assessment.

The teacher's resource guide provides tests, transparencies, posters, a generic science fair manual, and black line master worksheets to accompany activities and vocabulary study. Bibliographies for teachers and students are supplied in the text.

Extension activities are included in the "Going Further" section of each investigation. Some activities incorporate experimental design including one in the Life Science lab manual where students are asked to design and carry out an experiment to show the effect of mouth wash on the growth of bacteria. Others tend to be more simplistic: for example, one asks students to make a time line of average life spans of animals for which the class has collected data.

Technology.

Prentice-Hall markets two pieces of optional software that can be used with these texts. One is a bank of multiple choice test items. Teachers can also call Dial-A-Test™ to have customized tests made up. The other software is correlated to chapters in the text and includes review, reteaching, glossaries, basic skills instruction, and simulations.

Exemplary Science Features

Science content.

The science content provided in Prentice-hall Life Science, Physical Science, and Earth Science is substantial in terms of depth and comprehensive coverage of topics. A great deal of detailed information is presented in the text, including applications of science and technology. The teacher's edition prompts discussion on issues in science in every chapter while each unit includes an article on a science or technology issue in the section called "Science Gazette". Topics such as the safety of nuclear power, survival of rain forests, and the spread of the AIDS virus are discussed. Relevant applications of technology in science and in everyday life are presented.

Science process.

Scientific process is not as strong as content in these curricula. The laboratory activities enhance and reinforce the learning process; but they are not absolutely necessary for understanding of concepts presented in the text. It is possible for a teacher to ignore the lab possibilities and lecture from the book alone. There are no opportunities for real open-ended experimentation. Examples are: identifying elements by the flame test, constructing a solar collector, discovering what environments pill bugs prefer, and building a scale model of the solar system. The investigations spell out the procedures so that there are few decisions for students to make on their own. Extensions to investigations or evaluation questions sometimes ask students to design an experiment but usually it is not with the intention of having it carried out.

Each chapter features a career accompanied by a "Help Wanted" ad. The Science Gazette at the end of each unit features a scientist who is engaged in a special area of scientific work. An example is an article about Katharine Payne, who studies communication between African elephants. Few opportunities exist for significant solving of real problems, either independently or in groups. Contact with practicing scientists, community resources, or mentors is not promoted.

Tailoring for Special Populations

Differentiation for high ability learners.

The reading level of all three texts is aimed at junior high school students. However, each text (over 600 pages) requires much reading about advanced concepts, and includes high level vocabulary that would be challenging to high ability students. These learners would be capable of covering the content at an accelerated pace, which would mean covering more text and labs than an average ability learner. However, in a heterogeneously grouped class, this would be difficult to accomplish.

The science content in this series is substantial and is presented in detail. However, it is lacking in inquiry-based problems, open-ended activities, and opportunities for students to develop advanced products. Most of the extensions are too simplistic to provide these functions. The "Concept Review: Skill Building" section of each chapter review and "Critical Thinking and Applications" questions that appear at the end of lab activities in the lab manual are two of the few areas where higher order thinking skills are required. An optional set of Critical Thinking Skills Transparencies are available. They feature inferring, relating, applying, and predicting. However, most chapter objectives and assessment items require lower order skills.

Other special populations.

Suggestions are offered in the introduction to the teacher's edition of each text for teaching these special populations: learning disabled, hearing impaired, visually impaired, and physically disabled. The suggestions are not substantive but encourage sensitivity to the differences in these students. No mention is made of gifted learners as a special population. The career sections portray many positive role models for girls and minority students.

CONCLUSION

The Prentice-Hall series is a set of traditional junior high school text-based curriculum materials that are outstanding in terms of expository coverage of scientific concepts and applications of technology. However, the heart of the course is in the text. The program is lacking a built-in component of mandatory active involvement that teaches scientific process by simulating the activities of scientists. The texts are designed to reach as many students as possible but fail to provide opportunities for open-ended inquiry and complex applications that are essential in a program for high ability learners.

Curriculum Evaluation Form

Life/ Physical/ Earth Science (Prentice-Hall)

Phase I Review

Curriculum Design

3	2	1
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Average Rating

Reviewer #1

2.42

2.35

Reviewer #2

2.28

(Scale 1-3)

Classroom Design

3	2	1
---	---	---

Average Rating

Reviewer #1

2.30

2.23

Reviewer #2

2.15

(Scale 1-3)

Technology

3	2	1
---	---	---

Average Rating

Reviewer #1

NA

NA

Reviewer #2

NA

Phase II Review

Science Content

5	4	3	2	1
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Average Rating

Reviewer #1

4.67

4.71

Reviewer #2

4.75

(Scale 1-5)

Science Process

5	4	3	2	1
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Average Rating

Reviewer #1

2.79

2.58

Reviewer #2

2.36

(Scale 1-5)

Phase III Review

High Ability Learners

5	4	3	2	1
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Average Rating

Reviewer #1

2.75

2.67

Reviewer #3

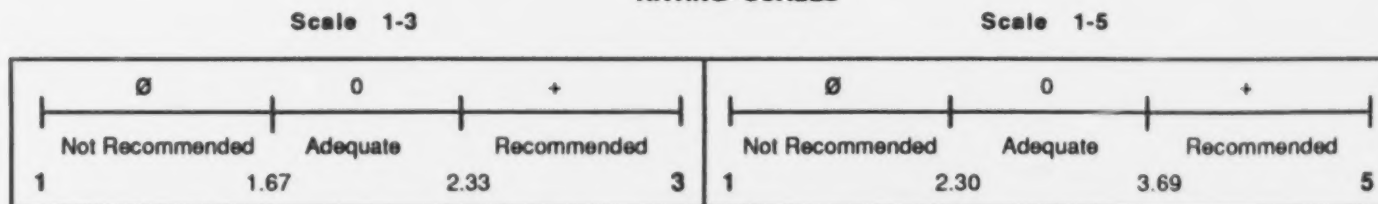
2.58

(Scale 1-5)

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Prentice-Hall	2.35	2.23	NA	4.71	2.58	2.67	
Life Science							
Physical Science	+	O		+	O	O	
Earth Science							

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Middle School Life Science

Grades 7-8

Jefferson County Public Schools

Golden, Colorado

Distributed by Kendall/Hunt Publishing Company

2460 Kerper Boulevard, P.O. Box 539

Dubuque, Iowa 52004-0539

1991

OVERVIEW

Description

Middle School Life Science is a one year comprehensive course in life science with emphasis on ecology and human biology. Unit titles are: Ecosystems and Ecology; Body Structure (bones, muscles, and skin); Foods and Digestion; Body Basics (circulatory, urinary, immune, and respiratory systems); Body Controls (senses, nervous system, and decisions and drugs); Body Changes (growth, reproduction, and birth); and Cells and Genetics. A student text, a teacher's guide and a teacher's resource book are the three basic components of the materials. The teacher's guide is used instead of a teacher's edition of the text and includes information on preparing for activities, teaching the lesson, background information, and answer keys for questions in the text. The teacher's resource book contains transparencies, optional lessons, additional print materials, and blackline worksheet masters.

Major Program Goals

The goal of the Middle School Life Science program is to enable students to:

- understand the structure and function of the various systems of the human body;
- understand the decisions necessary to improve a variety of wellness/health behaviors;
- understand basic ecological principles; and
- understand and develop solutions for environmental issues and problems.

Research Evidence of Effectiveness

The developers of Middle School Life Science conducted an evaluation of the program over a two year period from 1987-89. An experimental group of 654 seventh graders from Jefferson County were compared with a control group of 664 seventh grade students from Jefferson County and two neighboring districts. The control group used a life science curriculum that included all the major topics that are taught in the experimental curriculum. Four locally developed pre-tests and four locally developed post-tests measuring life science achievement were administered to both groups. The tests were: 1) Body Structure, Foods and Digestion; 2) Body Basics and Body Control; 3) Body Changes and Genetics; and 4) Ecology. During the first year of the field test, experimental group teachers had an average of one year of experience implementing the new curriculum; the experimental group out-performed the control group on three of the four areas measured and the effect sizes ranged from .10 to .62 on the four outcome measures. During the second year, experimental group teachers had an average of two years of experience with the curriculum; experimental group means were higher in all four areas while effect sizes ranged from .59 to 1.52. These effect sizes are interpreted by the researchers according to the following scale: .20 = small, .50 = moderate, and .80 = large. The results

were consistent across levels of ability and gender. However, the difference between means was greatest for high ability students in the three instances in which interactions between ability and treatment were significant. A second stage of analysis indicates that the higher performance of the experimental group was not due to superior teaching on the part of a few teachers. Based on this study, the developers conclude that students enrolled in the Jeffco (Middle School Life Science) program scored significantly higher on reliable tests of life science concepts, factual knowledge, and applications than students in other life science courses. (JEFFCO, 1989)

ANALYSIS

General Curricular Features

Curriculum design.

Middle School Life Science differs from most other "junior high school" life science texts in that it addresses relatively few topics in much greater depth. The design is consistent with current trends in philosophy about middle level education. It is developmentally appropriate for these students with many hands-on activities used to introduce concepts. The topics of ecology and the human body were chosen for their highly personal relevance for middle school students. Since more activities and readings are included than would be covered by a typical year-long course, teachers can select lessons that suit the students and course schedule. All lessons are labeled as core, recommended, or optional.

The program is organized around a learning cycle model that introduces topics with concrete experiences, followed by discussion, readings, demonstration, experiments, and finally, application in another situation. For example, the chapter on the respiratory system begins with students studying real x-rays of a healthy person and one with pneumonia; they look at a microscopic slide of *Streptococcus pneumoniae*, a kind of bacteria that often causes pneumonia. Then they learn about parts and functions of the respiratory system and symptoms and possible causes of disease. As an application activity, the effects of cigarette smoke on the lungs is examined by use of a simple lung model that is constructed by the students.

Classroom implementation.

Unlike most basal textbook programs, the activities in Middle School Life Science cannot be avoided. They are not in a separate lab manual or included at the end of each chapter; they are embedded in the text as an integral part of the program. The activities range from observation to designing and carrying out experiments. Many opportunities exist for cooperative group work. The program is not particularly interdisciplinary in nature but the extension activities make some connections such as further reading about Helen Keller, or about the unusual stomach experiments done by William Beaumont in 1825, or about the 1500 year old corpse that was found in a bog in Denmark. Extension activities follow each activity section of the text. These activities may involve getting more information from a library or an expert; or they may be doing a hands-on task such as soaking a chicken bone in acid and recording observations. Bibliographies with supplemental material are not included for students or teachers.

Teachers are well supported with advice in the teacher's guide. Cautions are provided where appropriate with comments such as "Students tend to answer this superficially," or "Blood

pressure measurements taken by students will not be accurate." Background information is provided for teachers on many topics. Instructional objectives for each section are contained in the teacher's guide with "focusing questions" given in the student activity sections. Students then carry out an activity to determine the answers to the focusing questions.

A strong assessment component is outlined in the teacher's guide. Many components are suggested for inclusion in each student's grade. Examples are quizzes, participation, data pages, tests, and notebooks. Creative homework assignments are encouraged. Authentic assessment is encouraged through the use of lab practicals. For example, students could be asked to identify specimens under a microscope or write their observations of a specimen that they have not seen before.

Technology.

No special technology features are included in this program.

Exemplary Science Features

Science content.

The Middle School Life Science curriculum covers fewer topics than most basal texts but they are covered in rich depth. The emphasis on ecology and human biology reflects the needs and interests of students this age. The presentation of all concepts is done in a way that is meaningful and relevant. Students should come away from this curriculum with a thorough and lasting understanding of the environment and their own bodies. The explanations are clear and simple. Complex ideas are conveyed accurately without unnecessary vocabulary.

Moral and ethical issues are included for discussion in a way that is relevant to seventh graders. One such dilemma is posed as a situation where a student is fishing with his friends who say that they can catch as many fish as they want because no one comes around to check whether they have exceeded the legal limit; students are to respond to the situation. Students are asked to "Take a Stand" on issues such as banning pesticides and limiting the number of children that people can have.

Science process.

The activity mode is dominant in this program and is valuable in teaching both content and process skills to seventh grade students. The activities are not the usual verification exercises where the student already knows what the outcome should be. For example, in the chapter on bones, students are asked, "How many differences can you observe between a dead bone and a living bone?" and "What is inside of a long bone?" Then they are given a fresh bone to inspect in order to answer the questions for themselves. In the environment unit, a particularly open-ended problem is cleverly presented to students in the form of a request from a hypothetical seed company that wants the students to find out about growing conditions for a new strain of their seeds so that this information can be included on the package.

Post-lab discussion is emphasized and is a valuable element of scientific process. Attention is called to possible sources of error, multiple interpretations of data, and alternative setups. Students are allowed to experience science as an active and dynamic process.

Some suggestions are made for students to consult community resources such as doctors, landscapers, veterinarians or a genealogical society for information on a topic. However, these suggestions are usually made in the extension sections of the text. No other formal career sections are included.

Tailoring for Special Populations

Differentiation for high ability learners.

This curriculum does not score high enough on the Phase III rating scale to make the "recommended" category for high ability learners. The reading level is not high. Interdisciplinary connections are not strong. The topics covered by this curriculum are not conceptually abstract. However, the information is exceedingly age appropriate and valuable for all seventh graders independent of their intellectual and academic capabilities. The treatment of the human body topics is more substantial than the usual coverage in a seventh grade health class but could be made to be even more challenging through the selection of questions and activities. Even though the questions that conclude each section or activity are called "Analysis Questions," they do not all require higher level thinking skills. Some ask for recall information such as "List at least four things that limit the size of a population." Others require higher levels of thought such as "Do you think there is a carrying capacity on earth for humans? Explain." By featuring and expanding questions such as the latter, teachers would be requiring a higher level of thought that would be more appropriate for high ability learners.

This is not a curriculum that would suit a self-contained class of gifted learners or a pull-out program. However, if this program is used with a heterogeneous class, the teacher must also address some needs of high ability students. In order to meet the needs of these students, the level of challenge would have to be adjusted by covering more of the sections, compressing some of the material, having students do some of it independently, and tapping the extension activities more fully. Since there is no bibliography one might be provided as a supplement. "Take a Stand" questions should be explored fully. Some opportunities for advanced products lie in the extensions or "challenge" sections but need to be highlighted, expanded, or supplemented to adequately serve the needs of these students. For example, an extension in the cell chapter asks students to "adopt a few amoeba or paramecia." They must find out what is required to keep them alive and monitor the population for a month. This could be expanded further by designing an experiment that tests the effects of heat, light, or different food on these organisms. The extension activities also suggest connections with community resources and practicing scientists that might be explored with high ability students.

Other special populations.

This curriculum contains no special features that are particularly advantageous to girls, minorities, or disabled students.

CONCLUSION

Middle School Life Science does a good job of in-depth treatment of both scientific content and process for middle school students in two carefully selected areas: the environment and the

human body. Clearly designed for this special age group, this program is likely to leave students with a firm understanding and appreciation of these two aspects of their lives. The style of the hands-on approach is appealing and meaningful. Though the program does not merit a "recommended" rating for use with high ability learners in the Consumer's Guide for this project, modifications could be made to make it particularly suitable for these students.

REFERENCES

"JEFFCO Life Science Program, Program Submission to the Program Effectiveness Panel at U.S. Department of Education," December 1989.

Curriculum Evaluation Form

Middle School Life Science (Kendall Hunt)

Phase I Review

Curriculum Design

3	2	1
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Average Rating

Reviewer #1

2.94

2.85

Reviewer #2

2.75

(Scale 1-3)

Classroom Design

3	2	1
---	---	---

Average Rating

Reviewer #1

2.67

2.70

Reviewer #2

2.72

(Scale 1-3)

Technology

3	2	1
---	---	---

Average Rating

Reviewer #1

NA

NA

Reviewer #2

NA

Phase II Review

Science Content

5	4	3	2	1
---	---	---	---	---

Average Rating

Reviewer #1

4.50

4.67

Reviewer #2

4.83

(Scale 1-5)

Science Process

5	4	3	2	1
---	---	---	---	---

Average Rating

Reviewer #1

3.93

4.11

Reviewer #2

4.29

(Scale 1-5)

Phase III Review

High Ability Learners

5	4	3	2	1
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Average Rating

Reviewer #1

3.33

3.38

Reviewer #3

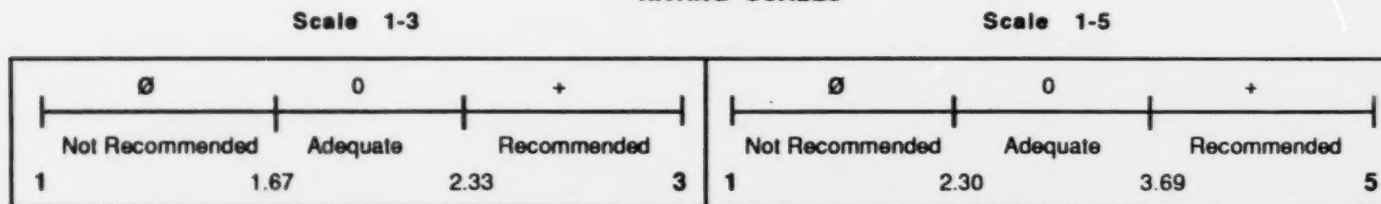
3.42

(Scale 1-5)

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Middle School Life Science (Kendall/Hunt)	2.85 +	2.70 +	NA	4.67 +	4.11 +	3.38 O	

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Science--A Process Approach (SAPA/SAPA II)
 American Association for the Advancement of Science
 Washington, D.C. 20005
 Distributed by Delta Education 1-(800)-258-1302

Grades K-6

OVERVIEW

Description

The original SAPA materials were developed in the 1960s and revised in the early 1970s as SAPA II. The program consists of 105 ungraded modules that concentrate on process skills in life science, physical science, and earth science. Each module is packaged in a storage box that includes a teacher instruction booklet, lab materials, worksheets, duplicating masters, and non-consumable student booklets. A more comprehensive Program Guide summarizes the program. An inservice training manual is also available. The program has no textbooks. SAPA II materials are available from Delta.

Major Program Goals

The Program Guide states the following goals.

At the end of the program the student should be able to:

1. Apply a scientific approach to a wide range of problems, including social ones, distinguishing facts from conjectures and inferences, and identifying the procedures necessary for the verification of hypotheses and suggested solutions.
2. Acquire an understanding of the sciences he or she will pursue in junior and senior high school more rapidly and with less difficulty than would otherwise be possible.
3. Identify each of the following in a printed or oral account of a scientific experiment: the question being investigated; the variables manipulated, controlled, and measured; the hypothesis being tested; the relationship of such a test to the results obtained; the conclusions that can legitimately be drawn.
4. Infer, where necessary, the question being investigated and the elements of scientific procedure in an incomplete account of a scientific experiment, such as might appear in a newspaper.
5. Design and, under certain conditions, carry out one or more experiments to test hypotheses relevant to a problem, providing the problem is amenable to scientific investigation and the content is within the child's understanding.
6. Show appreciation of, and interest in, scientific activities by choices made in reading, entertainment, and other kinds of leisure-time pursuits.
7. Develop values, attitudes, value systems, and value judgment criteria not only applicable to science-related experiences but also transferable to day-to-day experiences throughout life.

Research Evidence of Effectiveness

Many studies have been done on the science curricula developed in the 1960s. A quantitative synthesis procedure called "meta-analysis" that analyzes the results of this research was carried out by Shymansky, Kyle, and Alport (1983). Based on this analysis the authors conclude that there is a substantial body of literature that indicates that the science curricula of the 1960s were a successful attempt to improve science education. The following effect sizes for SAPA are included:

<u>Outcome Area</u>	<u>Effect Size</u>	<u>Number of Studies</u>
Composite	0.27	N = 45
Achievement	0.17	N = 12
Perceptions	0.39	N = 6
Process skills	1.08	N = 3
Analytic skills	0.06	N = 1
Related skills	0.10	N = 18

(Note: Effect size is defined as the mean difference between the treatment conditions divided by the standard deviation of the control group; a positive effect size indicates that students in the experimental curriculum performed better than the control group. Effect sizes in the range of below .30 are considered low, .30 -.45 modest, .45 -.60 moderate, and .60 and above high.)

Another report of their analysis of 34 studies on SAPA, ESS, and SCIS indicates the following results for students using the SAPA curriculum as compared to students using a traditional curriculum (Shymansky, Kyle, and Alport, 1982):

<u>Performance Area</u>	<u>Percentile Points Gained over Traditional Curriculum</u>
Achievement	7
Attitudes	15
Process Skills	36
Related Skills	4
(reading, arithmetic, communication)	
Creativity	7
Piagetian Tasks	12

Not only were process skill gains significant over traditional curricula but they were the greatest for SAPA (36 points gained) when compared to ESS (18 points gained) and SCIS (21 points gained).

Similar results were reported by Bredderman (1983) as the result of a meta-analysis that used 22 studies comparing SAPA students to those using a traditional curriculum. The results are summarized below in terms of effect size.

<u>Outcome Area</u>	<u>Mean Effect Size</u>
Science process	.71
Science content	.08
Affective Outcomes	.46
All Outcomes	.35

Bredderman also reported that:

- Two studies measured intelligence scores of students who used the SAPA program. One compared disadvantaged students who used SAPA for 15 weeks with a control group; an effect size of .60 was obtained favoring the experimental group (Johnson, 1970, cited in Bredderman, 1983). The other compared middle class students who used SAPA for 3 years with a control group and obtained an effect size of .36 favoring the experimental group (Kolebas, 1971, cited in Bredderman, 1983).
- Follow-up studies found no evidence to indicate that gains made during the use of SAPA were sustained in the years following the program.

However, a later meta-analysis was done by Shymansky, Hedges, and Woodworth (1986) using a refined statistical procedure to study the effectiveness of the three 1960's science curricula (SAPA, ESS, and SCIS). The published results do not separate the three but generally support, although not as strongly, the data obtained in the earlier study by Shymansky, Kyle, and Alport. In addition, it found that student performance was significantly enhanced by teacher inservice programs. Shymansky (1989) also reported the following significant findings:

- Students in the three experimental curricula (SAPA, ESS, and SCIS) outscored students in traditional curricula on a composite performance measure by 9 percentile points.
- Students using SAPA performed less well than traditional students by 7 percentile points in related skills (e.g., reading and math).
- Students' perceptions of the new science programs exceeded those of traditional students' by 17 percentile points.
- Process skills of students in the new curricula were 19 percentile points higher than those in traditional programs.
- Performance was significantly better in the three new programs than in traditional programs for both urban and rural classrooms that were balanced by gender and reflected medium and high SES.

ANALYSIS

General Curricular Features

Curriculum design.

The scope and sequence for SAPA is contained in two large charts that organize the 105 modules into 33 stages. Once students complete all modules in a stage, they may move on to the next stage. However, if a teacher wishes to select only portions of the curriculum, recommended "clusters" of modules are indicated on the chart. These are groups of modules that are related by process skills and objectives; they tend to be independent of each other. Classes that are starting the program after kindergarten must pick up skills that are covered in previous modules before moving ahead. Even though all modules identify prerequisites, key prerequisite

modules are designated as DEBUT (Delayed Entry Back-Up Topics) modules to be completed for this purpose. The program guide suggests that individual students who enter the program late can pick up skills from more experienced group members. Since modules need not be covered in numerical order and there is some flexibility in sequencing, an overall plan for use would need to be developed within each school and/or district.

The development of skills begins with the basics but gradually builds in complexity until the final year where experimentation is the focus. Kindergarten students use their senses to observe and classify while sixth graders design experiments, carry them out, and revise their hypotheses. Within each module, skills develop from an introductory level to a "generalizing experience" in which there is a transfer of skills from the previous activities.

Classroom implementation.

The SAPA program is designed to be an active, hands-on, process oriented curriculum. There is little written material for students so the role of the teacher is crucial in preparing the activities, initiating discussions, and providing the experiences that insure the learning of process skills. The teacher needs to be well prepared in science and trained in the use of this curriculum. The teacher's role is as a guide who lead students through a somewhat intricate set of activities. Even in instances where students are asked to think of ways to do things, the manuals make it clear that there is an intended route to get there. Students are encouraged to work together in a cooperative setting; this contributes to the process orientation of the curriculum.

Instructional objectives for each module are printed on the cover of each learning module. They are assessed in the "appraisal" and "competency measures" at the end of the module. These often include authentic assessment tasks (such as predicting the burning time of a candle under a container and then carrying out the activity). Traditional pencil and paper recall tests are not used. Teachers are also encouraged to monitor student progress on "tracking cards" and include observational assessments. Teacher inservice is recommended.

Some materials that are housed in different module storage containers are expected to be shared with other modules. The original module storage numbers are given in materials lists for location purposes. However, location and return of these items could present logistical problems unless duplicate sets of materials are purchased so that each module has a complete set of the necessary items.

Opportunities for extension activities are not common in this program. Bibliographies for students and for teachers are not included.

Technology.

No special technology features are included in this program beyond the usual laboratory equipment such as thermometers and equal-arm balances.

Exemplary Science Features

Science content.

The focus of SAPA is on the building blocks that make up the design and implementation of a scientific experiment. Coverage of the fundamentals of science is not a focus for this curriculum. Scientific concepts such as osmosis and magnetism are used as vehicles to study aspects of the experimental process rather than studied for their own sake. Concepts are mentioned only in sufficient depth for understanding of the lab experiences, rather than explored in depth. For example, identifying changes in growing plants and charting their growth is done in a module that features the skill of "observing". This is unlike a traditional content based curriculum that would have included these activities in a unit on "plants."

What science there is, is presented understandably and is not out of date. No attempt is made to establish the societal implications of science. Interdisciplinary or intradisciplinary connections are rare with the exception of the inclusion of mathematics topics where appropriate. For example, angle measure is taught in conjunction with reflection, and graphing and measuring are taught for their usefulness in scientific process.

Science process.

Two types of scientific processes are identified in the SAPA program:

Basic Processes

Observing
Using space/time relationships
Classifying
Using numbers
Measuring
Communicating
Predicting
Inferring

Integrated Processes

Controlling variables
Interpreting data
Defining operationally
Forming hypotheses
Experimenting

Most of the SAPA experiments are pre-designed. However, there are opportunities for children to set up and run their own experiments in some units, but they have to pull their variables from a predetermined list so these opportunities are not completely open-ended. Students have the opportunity to work in groups to perform the laboratory work. They are explicitly taught the elements of experimental design, including hypothesis creation, design of appropriate experimental protocols to answer a predetermined question, data collection, and data analysis. Each SAPA module focuses on different aspects of the experimental process. For a complete understanding of experimental design a student should experience as many of the modules as possible. The only step of the scientific process that is ignored in this curriculum is the step in which a scientist uses resources outside the laboratory to learn about the theoretical and experimental background of his problem and to establish the context in which it is important. Because the scientific topics used in SAPA are presented in so little depth, without any scientific context that would explain their importance, the motivation for doing an experiment will be difficult to supply.

Community resources are not tapped, connections with practicing scientists are not made,

careers are not discussed, and historical aspects of topics are not presented in the SAPA curriculum.

Tailoring for Special Populations

Differentiation for high ability learners.

The SAPA curriculum does a fine job teaching process skills but ignores the extended pursuit of content that high ability learners require. The extent to which guidance is provided insures that all students meet the goals of the program but for high ability learners a higher degree of open-endedness would be valuable. These learners are also capable of mastering these process skills at a faster rate than the recommended scope and sequence allows. Additional resources, such as books and practicing scientists would be helpful to extend content. More substantive ties to other disciplines and real world problems might motivate the study of science. The curriculum is particularly lacking in opportunities for development of advanced products. Some of these deficiencies could be remedied by the teacher but the materials strongly suggest doing the program "by the book."

Other special populations.

This curriculum includes no special features that are particularly advantageous to minorities, girls, or disabled students although the hands-on, cooperative learning environment could be beneficial.

CONCLUSION

The SAPA program teaches scientific process skills using a discovery laboratory approach that is carefully guided by the teacher. A student who works through the curriculum from start to finish should have a good grasp of the way scientists function. However, the program is lacking in real world problems to motivate investigation. Some scientific concepts will be learned as a by-product but content is not a primary focus of the curriculum. High ability learners may find the curriculum less challenging than needed in terms of depth of content, open-endedness, and opportunities for individualized extension.

REFERENCES

- Bredderman, T. (1983). Effects of activity-based elementary science on student outcomes: A quantitative synthesis. Review of Educational Research, 53(4), 499-518.
- Johnson, J.K. (1970) Effects of the process approach upon IQ measures of disadvantaged children. Science Education, 54, 45-47.
- Kolebas, P. (1971) The effects on the intelligence, reading, mathematics, and interest in science levels of third grade students who have participated in Science-A process Approach since first entering school (Doctoral Dissertation, University of Virginia, 1971). Dissertation Abstracts International, 1972, 32, 4443A. (University Microfilms No. 72-07-123)

- Shymansky, J.A. (1989). What research says about ESS, SCIS, and SAPA. Science and Children, 33-35.
- Shymansky, J.A., Hedges, L.V., Woodward, G. (1990). A reassessment of the effects of inquiry-based science curricula of the 60's on student performance. Journal of Research in Science Teaching, 27, 127-144.
- Shymansky, J.A., Kyle, W.C., and Alport, J.M. (1982, November/December). How effective were the hands-on science programs of yesterday? Science and Children, 14-15.
- Shymansky, J.A., Kyle, W.C., and Alport, J.M. (1983). The effects of new science curricula on student performance. Journal of Research in Science Teaching, 20, 387-404.

Curriculum Evaluation Form

Science - A Process Approach (SAPA)

Phase I Review

<u>Curriculum Design</u>	<table border="1" style="display: inline-table;"><tr><td>3</td><td>2</td><td>1</td></tr></table>	3	2	1	Average Rating
3	2	1			
Reviewer #1	2.64	2.59			
Reviewer #2	2.53	(Scale 1-3)			

<u>Classroom Design</u>	<table border="1" style="display: inline-table;"><tr><td>3</td><td>2</td><td>1</td></tr></table>	3	2	1	Average Rating
3	2	1			
Reviewer #1	2.33	2.21			
Reviewer #2	2.08	(Scale 1-3)			

<u>Technology</u>	<table border="1" style="display: inline-table;"><tr><td>3</td><td>2</td><td>1</td></tr></table>	3	2	1	Average Rating
3	2	1			
Reviewer #1	NA	NA			
Reviewer #2	NA				

Phase II Review

<u>Science Content</u>	<table><tr><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr></table>	5	4	3	2	1	Average Rating
5	4	3	2	1			
Reviewer #1	2.58	2.38					
Reviewer #2	2.17	(Scale 1-5)					

<u>Science Process</u>	<table><tr><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr></table>	5	4	3	2	1	Average Rating
5	4	3	2	1			
Reviewer #1	3.29	3.36					
Reviewer #2	3.43	(Scale 1-5)					

Phase III Review

<u>High Ability Learners</u>	<table border="1"><tr><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr></table>	5	4	3	2	1	Average Rating
5	4	3	2	1			
Reviewer #1	3.09	3.01					
Reviewer #3	2.92	(Scale 1-5)					

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Science - A Process Approach (SAPA)	2.59 +	2.21 O	NA	2.38 O	3.36 O	3.01 O	

RATING SCALES

Scale 1-3				Scale 1-5			
1	Ø	0	+	1	Ø	0	+
	Not Recommended	Adequate	Recommended		Not Recommended	Adequate	Recommended
	1.67	2.33	3		2.30	3.69	5

Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Science for Life and Living: Integrating Science, Technology, and Health
 Developed by The Biological Sciences Curriculum Study (BSCS)
 Kendall/Hunt Publishing Company, 1989 Experimental Edition
 2460 Kerper Boulevard
 P.O. Box 539
 Dubuque, IA 52004-0539

Grades K-6

OVERVIEW

Description

The Science for Life and Living curriculum centers on three unifying themes of science as a way of knowing, technology as a way of doing, and health as a way of behaving. Each grade level is additionally organized by a major concept and skill that integrates the themes of science, technology, and health. The major organizing concepts and skills at each grade level are listed below:

<u>Grade Level</u>	<u>Concept</u>	<u>Skill</u>
Kindergarten	Awareness of self and world	Observation/description
Grade 1	Order	Organization
Grade 2	Change	Measurement
Grade 3	Patterns	Prediction
Grade 4	Systems	Analysis
Grade 5	Energy	Investigation
Grade 6	Balance	Decisions

The Science for Life and Learning materials for each grade level consists of student texts (except for kindergarten), teacher's guide, and kits of materials. A program implementation guide serves as a resource for building-wide and district-wide planning, staff training, and the development of leadership teams.

Major Program Goals

The goal statement of Science for Life and Living reads:

Children should learn about science, technology, and health because they need to understand and use them in their daily lives and as future citizens. Education in the elementary years should sustain children's natural curiosity; allow children to explore their environment; improve children's explanations of their world; help children to develop an understanding and appreciation of science, technology, and health; and contribute to the informed choices children must make in their personal and social lives.

A scope and sequence chart outlines the concepts for each grade level in the three strands of science, technology, and health. Each unit then includes a list of outcomes for students such as the following for the "Ecosystems and Resources" unit for level six:

1. Identify interactions among the living and nonliving resources within an ecosystem.
2. Understand that ecosystems operate in a dynamic balance.
3. Predict what effect a change in the amount of available resources would have on the

balance within an ecosystem.

4. Make a considered decision about managing the resources in an ecosystem for the benefit of plants and animals.
5. Make and interpret a line graph.
6. Ask questions to help understand one another's point of view.

Research Evidence of Effectiveness

Science for Life and Living was evaluated by an external evaluator (Harms, 1991) using data collected from students, teachers, and principals during school year 1989-1990. Student data were collected through effective, cognitive, and self-report instruments administered before and after (pre and post) during a full year's instruction in both Science for Life and Living (treatment) and similar classrooms teaching a variety of other science programs (control). Teacher data were collected from treatment and control teachers at the end of the school year. Principal data were collected from principals of treatment schools at the end of the school year.

Pretest data on a large number of variables indicated that the treatment and control schools were similar in terms of student performance at the beginning of the test. Both control and treatment classrooms offered approximately 130 minutes of science instruction per week.

Harms organized his evaluation into three areas: 1) innovative, science or "paradigm shift," 2) student cognitive outcomes, and 3) student affective outcomes. The paradigm shift he cited includes: themes, depth rather than breadth, emphasis on principles or big ideas rather than facts, constructivism, and hands-on learning that develops rather than demonstrates stated concepts. Student cognitive outcomes were measured in four areas: 1) science content (energy and ecology), 2) health content, 3) science process/inquiry, and 4) inquiry-related themes. Student affective outcomes were measured by using generally accepted science attitude scales; measures were not developed to match the Science for Life and Living program.

Harms concluded that teachers responded very well to the paradigm shift in science instruction of Science for Life and Living. In fact, there was evidence that teachers found the program easier to teach than did the teachers of control classrooms with a variety of other programs. In addition, significant differences were found in the data for student cognitive outcomes and student attitudes outcomes that clearly favored the Science for Life and Living classrooms.

ANALYSIS

General Curricular Features

Curriculum design.

The authors of Science for Life and Living state that the special features of their program are the incorporation of science, technology, and health into one curriculum; the use of cooperative learning; and the implementation of an instructional model. The program is indeed unique because it integrates science, technology, and health with an instructional model consistent with constructivist learning theory. Within each unit, lessons proceed through the instructional model's five stages, or "five E's" of engage, explore, explain, elaborate, and evaluate. The model provides a sequence for learning and allows time for students to develop concepts and skills. It reflects the philosophy of the program which states, "students build on their prior knowledge,

construct their understanding over time, and develop personal explanations for events in their world."

The content of Science for Life and Living is based on concepts and skills, not the wide coverage of topics that is found in traditional texts. The authors intend for students to study fewer science concepts, to become more involved with exploration of the concepts, and to define the concepts for themselves. According to Bybee and Landes (1990), two criteria guided the content selection: "the knowledge selected should be fundamental to the structure of scientific disciplines and it should represent an integration across disciplines." At the sixth grade level which is organized around the concept of balance and the skill of making decisions, students study ecosystems and resources in the science unit, constraints and trade-offs in the technology unit, and communication and conflict during the health unit. The topical content found in traditional elementary textbooks occurs in Science for Life and Living only as vehicles to study the concept and to acquire the skill for that year.

The introductory sixth grade unit introduces the concept of balance and the IDEA method (Identify the problem, Describe all the options, Evaluate all the options, Arrive at a decision) for decision making. The second unit then uses ecosystems and resources to study balance and decisions in science. The following list of student activities for the "Ecosystems and Resources" science unit (which requires sixteen class sessions) provides an overview of the content in this unit.

- Students review picture stories of interactions between the living and nonliving resources in a salt marsh, oak forest, and tropical rain forest.
- Students play "Oh Deer!," a game that illustrates how a deer herd changes as the amount of resources change within the ecosystem, and they graph the results.
- Students study the annual growth rings of a tree for evidence of interactions between the tree and other living or nonliving resources around it.
- Students identify the connections between the living and nonliving resources within a salt marsh, oak forest, and rain forest ecosystem and debate whether the ecosystem of Yellowstone National Park is balanced naturally or artificially.
- Students survey the school yard to identify the connections among living and nonliving resources, decide how to improve the school year ecosystem for the benefit of plants and animals, and then carry out that decision.
- To evaluate their understanding of the unit, students are asked to decide what to do about a problem in a fictitious school yard ecosystem.

Classroom implementation.

The student text and teacher's manual for each grade level divides the year's work into four units. An introductory unit presents the major concept and skill for that year and establishes procedures for cooperative learning and managing materials. The concept and skill for the year are developed in the remaining three units, with a unit devoted to science, technology, and health.

Within each unit, the '5 E's' instructional model of engage, explore, explain, elaborate, and evaluate is developed through detailed sequential lessons. The lessons, one devoted to each stage of the model, may require one class session or as many as six. Kindergarten class sessions require 20 minute lessons; lesson length extends to a maximum of 60 minutes for sixth grade.

The teacher's manual and the student text are designed to complement one another, each containing essential information to fully implement the program. For instance, the teacher's manual contains detailed activities, strategies, and questions that go beyond the student text, and the student text often serves as a lab manual with procedures written for the team to follow.

The teachers' manual includes student outcomes for each lesson and lists ways in which students will show their achievement of the outcomes. Activities are accompanied by teaching strategies and commentaries that alert teachers to possible student responses and ways to encourage student inquiry. The detail in the teacher's manual is intended to support teachers who are new to hands-on science, cooperative learning, or the Science for Life and Living instructional model.

An assessment checklist that is provided for each unit enables teachers to record each student's achievement of the unit outcomes. Also, the evaluation lesson that concludes each unit requires students to synthesize and to demonstrate what they have learned. In the sixth grade evaluation lesson for the "Ecosystems and Resources" unit, students read about a problem in a fictitious school-yard ecosystem. Preliminary questions then ask students to identify living and nonliving resources in the ecosystem, to describe or draw a picture that shows how the resources connect to provide basic needs, and to state how removing a tree would affect the balance of the ecosystem. Finally, students are asked to propose a solution to the problem by using the IDEA method of decision making which was thoroughly taught in the preceding unit. The teacher's manual provides guidelines for assessing students' answers. The format of the evaluation lessons which use both individual assessment and cooperative-team assessment varies throughout the program to include activities that require hands-on work, diagrams or posters, and written answers to discussion questions.

Technology.

"Technology as a Way of Doing" is one of the three program elements in Science for Life and Living. Students learn about technology, use it, and invent it. However, this hands-on, inquiry based program does not utilize instructional devices such as video or computer technology.

Exemplary Science Features

Science content.

Science for Life and Living proposes to teach students scientific ways of thinking and life skills for healthy living. The authors of the program provide ample time for students to reconstruct their thinking and to practice skills. The identified concept and skills for each year are approached through science, through technology, and through health. Traditional elementary science topics and vocabulary receive less attention. In fact, the study of traditional science topics is limited, as the authors state in their philosophy.

In the sixth grade, students spend only 16 out of 55 weeks studying traditional science--ecosystems and resources. The rest of the year students are engaged in decision making, considering constraints and trade-offs such as might be encountered in a toy store sweepstakes and in learning communication skills. The technology unit uses a robot simulation, the toy store sweepstakes, an oil spill problem, a gasoline question, and the options of diapering babies to consider the relationship of constraints and trade-offs to balance and decisions. At times, the

constraints and trade-offs considered in this unit consist of personal values but avoid opportunities to consider scientific problems. For instance, the diapering babies segment discusses cost and convenience but not issues of water supply and pollution.

Science process.

The authors of Science for Life and Living state that scientists do not use one scientific method in their work; instead, they use a variety of methods and processes. The methods and processes addressed in the curriculum include observing, measuring, recording observations, talking to others, writing about findings, reading about others' findings, refining questions, gathering and analyzing additional data, making predictions, and asking more questions. Students have numerous opportunities to do science and the curriculum makes the distinction between "guess" and "predict," a distinction frequently not made in other curricula.

As an integrated curriculum, Science for Life and Living is particularly strong in thinking skills, problem solving, communications skills, and decision making. These skills receive specific attention, and students have opportunities to practice them in a variety of contexts.

Tailoring for Special Populations

Differentiation for high ability learners.

The authors of Science for Life and Living stress that the program is for all students. However, they address the needs of students with limited experiences rather than the needs of gifted learners. The program does not include content or problems of sufficient complexity to challenge gifted learners.

In addition, the authors of the program state that children are usually content to observe phenomena, experiment, and observe the results; that children do not expect the same kind of detailed answers and logical explanations sought by adults. Therefore, the authors strongly recommend that teachers not share the explanations contained in the "information for the teacher" sections with students. However, teachers who are cognizant of the demands of inquiry based science and sensitive to the complex information needs of gifted learners might find the "information for the teacher" useful for gifted learners. For instance, the "Fat Finger" lesson in the second grade "Comparison and Evidence" unit includes information for the teacher on optical illusions that could be structured into an independent study opportunity for gifted learners. However, the adaptations necessary to make this curriculum appropriate for gifted learners would require a large commitment of time and effort from the teacher.

Other special populations.

Science for Life and Living consciously addresses involving girls and minority students through cooperative learning, gender-free language, and illustrations that show both boys and girls from diverse ethnic groups. In addition, the teacher's manual includes specific suggestions for encouraging girls and minority students to actively participate in all aspects of the program.

The program does not specifically address the needs of disabled students.

CONCLUSION

Science for Life and Living is unique in its comprehensive scope and in its attention to structuring integrated learning experiences in the areas of science, technology, and health. It is an elegant plan for teaching students strategies for lifelong learning and careful decision making. In this program students learn concepts and skills necessary for informed, healthful living in contexts that are relevant to their lives.

The time Science for Life and Living allows for students to master skills and concepts is a radical departure from existing textbook curriculum and practice. The authors have made a conscious choice to present a limited number of concepts and skills from multiple vantage points of science, technology, and health rather than covering many topics superficially. As an effort for national reform at the elementary level, the program offers a choice that demands careful consideration.

However, the Science for Life and Living neglects the intellectual needs of gifted learners. For gifted learners, the program must be supplemented with more complex content and problem solving opportunities. Although an exciting, exemplary program, Science for Life and Living illustrates the impossibility of constructing one curriculum to serve all the nation's children.

REFERENCES

- Bybee, R.W., & Landes, N.N. (1990). Science for life and living: An elementary school science program from Biological Sciences Curriculum Study. The American Biology Teacher, 52, 92-98.
- Harms, N. (1991). BSCS Science for Life and Living: An Evaluation Report From an External Evaluator. Unpublished manuscript, Biological Science Curriculum Study, Colorado Springs, CO.

Curriculum Evaluation Form

Science for Life and Living

Phase I Review

<u>Curriculum Design</u>	3 2 1	Average Rating
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Reviewer #1	2.53	2.57
Reviewer #2	2.61	(Scale 1-3)

<u>Classroom Design</u>	3 2 1	Average Rating
-------------------------	-----------	----------------

Reviewer #1	2.59	2.64
Reviewer #2	2.68	(Scale 1-3)

<u>Technology</u>	3 2 1	Average Rating
-------------------	-----------	----------------

Reviewer #1	NA	NA
Reviewer #2	NA	

Phase II Review

<u>Science Content</u>	5 4 3 2 1	Average Rating
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Reviewer #1	2.44	2.78
Reviewer #2	3.11	(Scale 1-5)

<u>Science Process</u>	5 4 3 2 1	Average Rating
------------------------	-------------------	----------------

Reviewer #1	3.41	3.58
Reviewer #2	3.75	(Scale 1-5)

Phase III Review

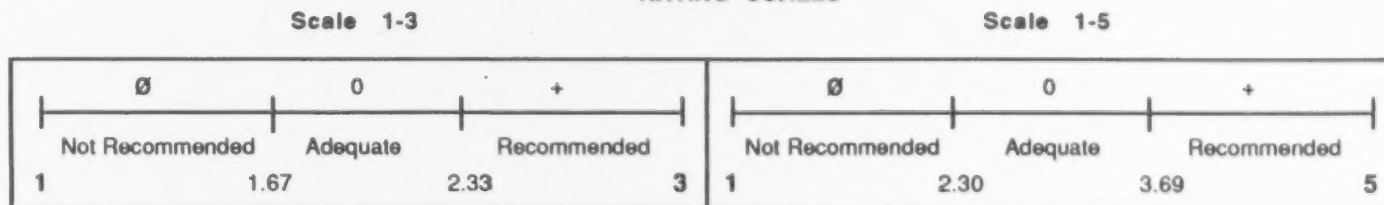
<u>High Ability Learners</u>	5 4 3 2 1	Average Rating
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Reviewer #1	2.16	2.50
Reviewer #2	2.75	(Scale 1-5)
Reviewer #3	2.58	

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Science for Life and Living	2.57 +	2.64 +	NA	2.78 0	3.58 0	2.50 0	

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Science and Technology
 Coronado Publishers
 (Now distributed by HBJ, Orlando, FL)
 1985

Grades 1-6

OVERVIEW

Description

Science and Technology is a basal textbook series that explores the close relationship between science and technology. Instructional materials for each grade level include a student textbook, a teacher's guide, and a teacher's resource book that includes worksheets, transparencies, and tests (in both English and Spanish). A materials kit that provides the supplies for carrying out activities is also available. In the upper grades a workbook replaces the worksheets.

Major Program Goals

No major goals or objectives are stated for this program.

Research Evidence of Effectiveness

No research evidence is available for the effectiveness of Science and Technology. Rather, the publishers conducted field testing or market research during the development stages of the series. Market research includes surveying the literature of educational research and educational reform movements to determine current trends. In addition, teachers are polled and students interviewed in order to improve the product. Summaries of the field testing or market research are then made available to textbook adoption committees in various forms such as "Learner Verification" reports.

ANALYSIS

General Curricular Features

Curriculum design.

Science and Technology is organized around year-long themes. The first theme, "Things Around Us," features topics that are familiar to first grade students. Subsequent themes are "Changes Around Us," "Changes We Make," "Our Planet Earth," and "Planet Earth in Space." The themes progress into broader scope and complexity of topics, culminating in sixth grade with "In a New Age" that includes the study of the solar system and space travel. Life, matter, and energy are the three "wide categories," or patterns, that unify the themes.

This curriculum looks at how science facilitates technological advances and how technology supports science. Examples are: fighting forest fires, purifying drinking water, replacing burned skin, and generating power with a nuclear reactor. The applications of technology become more frequent in the upper grade levels.

The material is presented in a developmentally progressive way. Beautiful color photographs take the place of most written text in the first two grades and hands-on activities are

predominant. However, the early grade levels may keep students on a concrete reasoning level longer than necessary. The upper grade levels feature more reading along with more abstract concepts.

Classroom implementation.

Activities in the books for grades 1-4 are often suggested through sections called "Let's Find Out" and "Now Try This." Some of the activities tend to be simplistic. These activities are core portions of the curriculum and yet teachers and students may be deterred from doing them since there are often such accurate photographs of outcomes that conclusions can be drawn just by looking at the picture. Accompanying investigation worksheets or workbooks could be used instead of the text in order to minimize this problem. Many of the activities in grades 5 and 6 are demonstrations of scientific principles but are also depicted in photographs. Few opportunities for open-ended problem finding or problem solving are included since most problems and procedures are spelled out for students.

Grouping procedures are noticeably absent but it would be best to form small groups during activities to encourage discussion at each step of the way.

Assessment of student progress is done primarily by traditional forms of post-testing. The teacher's editions also include assessment questions for use in classroom discussion. Unit assessment questions follow each chapter and unit in the student text; additional test questions appear in the teacher's resource book. However, most are "multiple choice" or "fill in the blank" items with few opportunities for open-ended responses. In the primary grades students might be able to pass the tests before the unit it taught. No provision for observational or product assessment is suggested in the materials.

The teacher's editions of textbooks for grades 1-4 alert them to connections between science and technology and other areas such as math, art, and language arts. Most are suggested as extension or reinforcement activities. Some support valid interdisciplinary connections such as drawing and labeling the parts of a plant. Others, such as making a mouse out of milkweed pod, do not directly support the study of science and technology.

A list of resource materials including films, computer software in grades 5 and 6, additional readings for students, and teacher references appear in the teacher's editions. The teacher's resource book contains substantial supportive materials such as worksheets, tests, and transparencies that should all be used but should not be considered adequate replacements for additional hands-on science experiences.

Enrichment and extension activities are suggested in the teacher's editions of texts. There are many worthwhile ideas, but many of them should be required of all students. For example, an enrichment activity in grade 3 asks students to compare cells from inside one's cheek to leaf cells under a microscope. In grade 5, learning about cloud types is included as an extension activity. Many of these valuable experiences may go unnoticed since they are included in the margins of the teacher's text and therefore not identified as essential. Open-ended extensions are rare and need to be sought out by teachers if higher level thinking skills are to be encouraged. Teachers need to emphasize the activities that pose a question and ask "How can you find out?"

Technology.

Despite the title of the series there is little technology included for actual use by students. Technology is discussed a great deal and wonderful examples of its applications are contained in the reading. Other than the use of the usual science lab equipment, there is no special use of technology. Resource lists suggest software that can be obtained independently but no computer activities are included in the curriculum.

Exemplary Science Features

Science content.

Science and Technology includes a good content base in science concepts and technology. The overarching patterns of life, matter, and energy integrate life, physical, and earth sciences. Interdisciplinary connections with other academic areas are identified but are not a central focus of the series. However, the presentation of real world applications of technology are convincing and motivating to the study of science. Mathematical support for the science and technology activities is not emphasized.

The teacher's editions of these texts do not include additional background information for teachers. Some of the content in this curriculum is implicit and requires a teacher who has some background in science. Students should be prompted to think about questions and answers that are not explicitly stated in the text.

A good deal of significant material, often in the form of experiments, is lurking in the extension sections and should not be overlooked. Some of the moral and ethical questions that arise with the development of modern technology are not addressed directly in the texts. However, they may be if students are asked to collect current news articles or if speakers are invited to the classroom as is sometimes suggested in extension ideas. Teachers need to be alert to these opportunities and must promote students' critical thinking, especially in terms of issues concerning the use of technology. Otherwise students may complete this curriculum with a view that all advances in modern technology are always beneficial.

Science process.

Not all of the activities fully promote scientific process skills. Most of the problems are formulated for the student and are accompanied by detailed procedures. Desired outcomes are sometimes disclosed to students before they carry out the activity. The feeling of surprise that is often experienced by scientists is missing and there are few opportunities to experience examples of unsuccessful science.

Tailoring for Special Populations

Differentiation for high ability learners.

In the early grade levels of Science and Technology highly able learners may not be challenged by the reading level or depth in concept coverage. Many activities that would be most interesting to them are embedded in enrichment ideas.

In the margins of the teacher's editions for grades 5 and 6, there are sections called "Planning for Special Needs" that give extension activity ideas. The suggestions that would apply to high ability learners usually ask students to research a topic in the school library or consult a high school text to find out more about a topic. This presents the danger that highly able learners in a heterogeneously grouped class might be parked in the library to learn on their own. There is little authentic science suggested as extension work and few opportunities provided for students to develop an advanced product other than a report.

All grade levels lack application of higher level thinking skills and opportunities for open-ended investigation; essentials in a curriculum for gifted learners. A teacher would have to select, modify, and supplement activities to make them challenging to gifted learners.

Other special populations.

This curriculum includes no special features that are particularly advantageous to girls, minorities, or disabled students.

CONCLUSION

The strength of this curriculum is in its portrayal of the inter-connectedness of science and technology. Although Science and Technology contains valuable information for all students, it does not address the additional needs of gifted learners through its basic materials and activities. It lacks the problem-oriented inquiry emphasis that promotes creativity and higher level thinking skills.

Curriculum Evaluation FormScience and TechnologyPhase I ReviewCurriculum Design

3 2 1

Average Rating

Reviewer #1

2.46

2.23

Reviewer #2

2.00

(Scale 1-3)

Classroom Design

3 2 1

Average Rating

Reviewer #1

2.11

2.07

Reviewer #2

2.02

(Scale 1-3)

Technology

3 2 1

Average Rating

Reviewer #1

NA

NA

Reviewer #2

NA

Phase II ReviewScience Content

5 4 3 2 1

Average Rating

Reviewer #1

4.08

4.29

Reviewer #2

4.50

(Scale 1-5)

Science Process

5 4 3 2 1

Average Rating

Reviewer #1

2.43

2.77

Reviewer #2

3.10

(Scale 1-5)

Phase III ReviewHigh Ability Learners

5 4 3 2 1

Average Rating

Reviewer #1

2.79

2.80

Reviewer #3

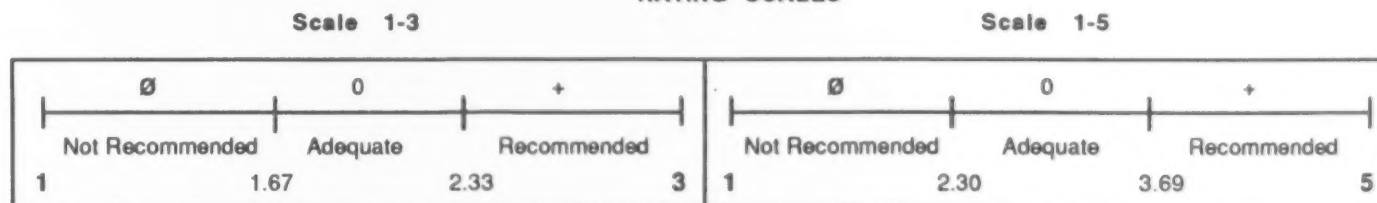
2.80

(Scale 1-5)

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Science and Technology	2.23 O	2.07 O	NA	4.29 +	2.77 O	2.80 O	

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Science Horizons

Silver Burdett & Ginn

160 Gould Street

Needham Heights, MA 02194-2310

1991

Grades K-6**OVERVIEW****Description**

Science Horizons is a new basal textbook series for the primary and elementary grades. Beyond the student texts and teacher's editions, a large number of supplemental resources are available. They include a student resource book, activity masters, transparencies, chapter and unit tests, computer software, science equipment kits, "Beyond the Horizon" enrichment cards, a professional handbook of teacher resources, a Connections book that suggests links to other disciplines, posters, and Big Shared Books that share the core lessons of a unit and include a literature selection relating to the unit. A Spanish language edition of the text is also available.

Major Program Goals

No overarching goals or objectives for the program are stated .

Research Evidence of Effectiveness

No research evidence is available for the effectiveness of Science Horizons. Rather, the publishers conducted field testing or market research during the development stages of the series. Market research includes surveying the literature of educational research and educational reform movements to determine current trends. In addition, teachers are polled and students interviewed in order to improve the product. Summaries of the field testing or market research are then made available to textbook adoption committees in various forms such as "Learner Verification" reports.

ANALYSIS**General Curricular Features****Curriculum design.**

A very thorough and well documented rationale for all aspects of the curriculum is presented in the introduction to Science Horizons. Four scope and sequence charts are included for: content, science process skills, concepts and objectives, and activity objectives. They move on a continuum from simple to complex, from general to specific, and from concrete to abstract.

The curriculum incorporates the study of life, earth, and physical sciences and the human body over all grade levels. Life science includes ecology and living things. Physical science includes the study of matter and energy. Earth science covers space, earth, and weather.

Classroom implementation.

The main teaching strategy that is modeled in the teacher's edition is a three step process: 1) "Focusing the Lesson" includes a warm-up exercise and introduction to vocabulary. 2) "Developing the Lesson" includes guided learning by discussion of information read or observed in the text and is usually followed by an activity and questions to check comprehension. 3) "Closing the Lesson" involves a summary and a connection of the lesson to another area of science. Every lesson is accompanied by more than two additional pages of optional teacher support that include: background information, common student misconceptions, extension and enrichment ideas, suggestions for reteaching, activities for mainstreamed students, tips for teaching students with limited English proficiency, interdisciplinary connections, and detailed notes on activities included in the unit.

One of the following five types of activities appears in each lesson:

- Discover, which is an opening activity for a chapter.
- Explore, which is a guided-learning, hands-on activity.
- Explore Together, which is a cooperative learning activity.
- Skills, which is focused on science process thinking skills.
- Problem Solving, which is based on a four-step model that promotes thinking skills.

In addition to these types of activities there are more ideas available in the Professional Handbook and in the Beyond the Horizon cards (targeted for gifted learners). A good supply of hands-on activities are presented but they could be overlooked if a teacher is pressed for time. It is essential that this not happen.

Every lesson has well formulated objectives followed by assessment questions at the end of the lesson. Tests are included in an additional test book. No other types of assessment are suggested.

Additional reading material is listed in bibliographies that are included at the end of each teacher's manual; books for teachers, non-fiction books for students, periodicals for students, and periodicals for teachers are listed. Science content is connected to literature through excerpts from the Big Shared Books. Additional literature extensions are listed at the end of each unit.

A wide variety of extension activities are suggested in the teacher's manual. Field work, library research, experiments, demonstrations, and problem solving are included. Some are challenging and open-ended. For example, in grade 2 students are asked to use a field guide to identify wildflowers. A sixth grade extension asks students to design and build a model of an earthquake resistant house.

No mention is made in the materials about learning centers. However, since there are so many activities and reading extensions suggested, it would be advisable for the teacher to place some of these materials in independent learning center format so that they can be used by interested students.

Technology.

Computer software can be purchased but was not included with the materials that were reviewed.

Exemplary Science Features

Science content.

In Science Horizons, many important scientific topics are introduced, often with advanced vocabulary and mention of very sophisticated concepts. For example, the sixth grade book mentions topics such as covalent bonding, the chemical and physical properties of the different elements, the organization of the different elements, and the organization of the periodic table in its discussion of chemistry. While each of these areas is mentioned, none of them is covered in sufficient depth for useful understanding. The discussion of covalent bonding, for example, neglects the concepts of valence and bond angle. While these concepts may be too advanced for sixth graders, it is not meaningful to discuss covalent bonding without them. Indeed, one suggested activity in this section is having the students make molecular models of simple compounds based on their formulae; such models cannot be made properly without an understanding of bond angle and valence. Thus, the activity is too sophisticated for the understanding of the students given the information available to them in the book. Similar situations recur throughout the text. Coverage of important topics is peripheral, rather than deep; attention is paid more to vocabulary than to meaningful concept development. More, in this case, is less.

Interdisciplinary and intradisciplinary linkages are mentioned in Science Horizons. Sections called "Science, Technology, and Society" relate science to modern technology and problems. Each of these items gives a very brief description of a technological application of some area of science. From these sections teachers should extend discussions of technology-related issues (i.e., toxic waste dumps, consumer product testing) to reinforce the coverage of these areas in the text. Links between scientific disciplines are made in the closing portion of each lesson in the teacher edition but not made in the student text. The connections between science and other fields of study, such as mathematics, are made primarily in the optional activities. Thus, it is the teacher's responsibility to be sure that these activities happen and that these linkages are made for students.

Science process.

Science process skills are taught mainly through the laboratory activities and problem-solving exercises. Numerous activities are suggested, usually one in each lesson. However, most of the labs are verification exercises. An example is covering flashlights with colored cellophane to show how white light can be made from colored light. Some, such as designing and conducting an experiment to see whether sugar or salt will dissolve in a smaller amount of water, involve higher order skills. It would be easy to slide past many of these, citing lack of time or materials, but these activities are essential if any scientific process skills are to be practiced by students.

Tailoring for Special Populations

Differentiation for high ability learners.

The basic Science Horizons curriculum alone would not be adequate for high ability learners. The challenging situations that are included in the student text must be highlighted for these students even though the core curriculum does not require them to be done. Opportunities to develop higher level thinking skills are often found in the activities labeled "Problem Solving." For example, one such problem for grade 2 asks students to invent a device to safely transport the egg of an endangered animal. A grade 5 problem asks students to construct different classification systems for the first 25 elements of the periodic table. Second graders are asked to identify a mystery substance called "Goo" as a solid, liquid, or gas; they form a hypothesis and test it but get ambiguous results. These activities are extremely valuable for high ability learners but may not be touched if left to the choice of a teacher.

The program includes other supplementary resources that would enhance the program for high ability students:

- Beyond the Horizon extension activity cards.
- A student bibliography.
- Literature extensions.
- Information is provided about the Invention Convention, which includes a good opportunity for students to develop an advanced product for purposes of entering it in a competition.
- The extension sections include some challenging ideas. For example, second graders are given a hypothetical problem where the town's water supply has become contaminated; they must develop a plan for providing clean water for drinking and bathing.

If a teacher only accomplishes the basic elements of Science Horizons, s/he will not be serving high ability students. In a homogeneous, high ability group, content can be accelerated so that more time can be spent on in-depth discussions and extensions. In a heterogeneously grouped class, high ability learners need to be grouped together from time to time so that they can support each other in more challenging extensions and projects.

Other special populations.

This curriculum shows no special advantages for girls, minorities, or disabled students.

CONCLUSION

Science Horizons covers a broad range of topics in science but perhaps at a superficial level. In attempting to cover so many topics the series sacrifices some depth of coverage. The program includes many activities that can benefit a wide range of ability levels. Although the basic components are not sufficiently challenging for high ability learners, the possibility exists for this curriculum to be used successfully with them by carefully selecting activities and extensions that emphasize higher level thinking skills and scientific process. However, supplementary materials and activities would still be necessary, especially in providing 1) opportunities for developing advanced products, 2) extensions that involve more complex applications of concepts, and 3) opportunities for students to interact with scientists.

Curriculum Evaluation Form

Science Horizons

Phase I Review

Curriculum Design

3	2	1
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Average Rating

Reviewer #1

2.55

2.74

Reviewer #2

2.93

(Scale 1-3)

Classroom Design

3	2	1
---	---	---

Average Rating

Reviewer #1

2.79

2.79

Reviewer #2

2.79

(Scale 1-3)

Technology

3	2	1
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Average Rating

Reviewer #1

NA

NA

Reviewer #2

NA

Phase II Review

Science Content

5	4	3	2	1
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Average Rating

Reviewer #1

4.08

3.50

Reviewer #2

2.91

(Scale 1-5)

Science Process

5	4	3	2	1
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Average Rating

Reviewer #1

3.57

2.93

Reviewer #2

2.29

(Scale 1-5)

Phase III Review

High Ability Learners

5	4	3	2	1
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Average Rating

Reviewer #1

3.58

3.58

Reviewer #3

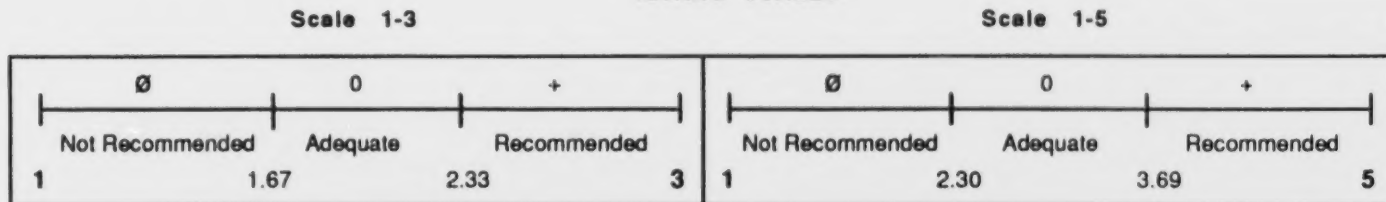
3.58

(Scale 1-5)

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Science Horizons	2.74	2.79	NA	3.50	2.93	3.58	
	+	+		O	O	O	

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

SCIIS--Science Curriculum Improvement Study**Grades K-6**

Developed by Lawrence Hall of Science, University of California at Berkeley

Delta Education

P. O. Box 915

Hudson, NH 03051-0915

1988

OVERVIEW**Description**

SCIIS (spelled with two i's) is a revised version of the Science Curriculum Improvement Study (SCIS) developed under the direction of Robert Karplus, a physicist at the University of California, Berkeley. The original program which began in 1961 received funding from the National Science Foundation. Commercial editions and a major revision begun in 1976 resulted in the current Delta Education SCIIS program used for this review. The third generation or major revision of the program, SCIS 3, will be available from Delta Education in the fall of 1992.

SCIIS develops scientific literacy that focuses on concepts and processes through a hands-on learning cycle of exploration, "invention," and discovery. The program starts with a year-long kindergarten "Beginnings" unit, then proceeds through a physical/earth science sequence and a life/earth science sequence for grades one through six. The two parallel and complementary sequences are intended to occupy half of the year at each grade level, thereby allowing two classes to share equipment and materials.

Materials for each grade level include a teacher's guide, student journals, an equipment and materials kit, and sets of "Extending Your Experience" cards. In addition, shipments of live organisms are included for the life and earth science units. There are no textbooks.

Major Program Goals

SCIIS seeks to develop scientific literacy derived from basic knowledge, investigative experience, and curiosity. By enabling students to cope with unexpected findings, the developers of SCIIS seek to help students learn science as well as a scientific approach to reasoning and decision making.

Research Evidence of Effectiveness

Many studies have been done on the science curricula developed in the 1960s. A quantitative synthesis procedure called "meta-analysis" that analyzes the results of this research was carried out by Shymansky, Kyle, and Alport (1983). Based on this analysis the authors conclude that there is a substantial body of literature that indicates that the science curricula of the 1960s were a successful attempt to improve science education. The following effect sizes were found for SCIS:

<u>Outcome Area</u>	<u>Mean Effect Size</u>	<u>Number of Studies</u>
Composite	0.30	N = 45
Achievement	1.00	N = 5
Perceptions	0.09	N = 14
Process Skills	0.56	N = 6
Related Skills	0.21	N = 13

(Note: Effect size is defined as the mean difference between the treatment conditions divided by the standard deviation of the control group; a positive effect size indicates that students in the experimental curriculum performed better than the control group. Effect sizes in the range of below .30 are considered low, .30 -.45 modest, .45 -.60 moderate, and .60 and above high.)

Another report of their analysis of 34 studies on ESS, SAPA, and SCIS indicates the following results for students using the SCIS curriculum compared to students using a traditional curriculum (Shymansky, Kyle, and Alport, 1982):

<u>Performance Area</u>	<u>Percentile Points Gained over Traditional Curriculum</u>
Achievement	34
Attitudes	3
Process Skills	21
Related Skills	8
Creativity	34
Piagetian Tasks	5

Similar results favoring SCIS were reported by Bredderman (1983) who conducted a meta-analysis on studies that compared SCIS students to those using a traditional curriculum. The results are summarized below in terms of effect size.

<u>Outcome Area</u>	<u>Mean Effect Size</u>	<u>Number of Studies</u>
Science process	.43	N = 14
Science content	.26	N = 6
Affective Outcomes	.14	N = 9
All Outcomes	.34	N = 28

However, a later meta-analysis was done by Shymansky, Hedges, and Woodworth (1986) using a refined statistical procedure to study the effectiveness of three 1960's science curricula (SAPA, ESS, and SCIS). The published results do not separate the three but generally support, although not as strongly, the cumulative data obtained in the earlier study by Shymansky, Kyle, and Alport. In addition it found that student performance was significantly enhanced by teacher inservice programs. Shymansky (1989) also reports the following significant findings:

- students in the experimental curricula (SAPA, ESS, and SCIS) outscored students in traditional curricula on a composite performance measure by 9 percentile points.
- students' positive perceptions of the new science programs (i.e., attitudes towards science) exceeded those of students in traditional programs by 17 percentile points.
- process skills of students in the new curricula were 19 percentile points higher than those in traditional programs.

- SCIS showed significant gains in achievement, process skills, perceptions, and analytic skills.
- performance was significantly better in the three new programs than for traditional programs for both urban and rural classrooms that were balanced by gender and reflected medium and high SES.

Using a two-part "opinionnaire," Atwood and Howard (1990) studied teacher perceptions of SCIS-II. They were specifically studying the barriers to implementing an investigative approach to elementary science and why there is not a greater utilization of programs proven effective by research. Atwood and Howard asked teachers what did not work well and what improvement was most needed in each section of each unit. Teachers of grades 3-6 perceived more barriers than teachers of grades K-2. Problems with student management, equipment and living materials, and with unexpected results were reported as difficulties by teachers of grades 3-6. The investigators point out that textbook publishers have borrowed many of the ideas from the successful investigative science programs (SCIIS, SAPA, and ESS) but not the philosophy of investigative science. They speculate that perhaps textbook publishers have not adopted a philosophy of investigative science because of their sensitivity to teacher perception. In addition, Atwood and Howard contend that larger numbers of teachers would persist with teaching investigative science if some of the obvious barriers of curriculum management were reduced through revised or new "teacher friendly" programs.

ANALYSIS

General Curricular Features

Curriculum design.

Interaction, the central concept of SCIIS and of modern science according to SCIIS, is elaborated upon by the study of the major concepts of matter, energy, organism, and ecosystem. Five process-oriented concepts: property (or characteristic), variable, system, reference object, and scientific theory provide the basis for observing, describing, comparing, classifying, measuring, interpreting evidence, predicting, and experimenting. Scientific attitudes, of curiosity, inventiveness, critical thinking, and persistence complete the quest for scientific literacy in SCIIS. These concepts, processes, and attitudes provide structure and sequence for the content of SCIIS which is shown in the following chart:

SCIIS Content		
K	Beginnings	
	Physical/Earth Science Sequence	Life/Earth Science Sequence
1	Material Objects	Organisms
2	Interaction and Systems	Life Cycles
3	Subsystems and Variables	Populations
4	Relative Position and Motion	Environments
5	Energy Sources	Communities
6	Scientific Theories	Ecosystems

The developers of SCIS designed the program's conceptual themes and activities to match the intellectual development of children as it is described by the theories of Piaget (Eakin & Karplus, 1976). Although the developers emphasized preoperational and concrete operations, they recognized that children in any group would be working at different stages. Therefore, they designed the investigations to accommodate those differences. As one of several examples, the developers cite the various ways that students can investigate electric circuits with increasing complexity in the sixth-level physical science unit. For instance, a child may attempt to light the bulb as brightly as possible through trial-and-error (preoperational); or most children recognizing the conditions of open and closed circuits will classify objects as conductors and nonconductors and build their circuits accordingly (concrete operational); and a few children will contribute ideas to the formulation of a scientific model for electricity (formal operational). Throughout the program, the theme of interaction is carefully developed through a sequence of hands-on investigations that enable students to construct meaning for themselves.

Classroom implementation.

SCIIS is based on a three-stage learning model of "exploration," "invention," and "discovery." Karplus (1971/1973) describes "exploration" as self-directed, unstructured investigation; "invention" as the introduction of a new integrating concept by the teacher or by the learner; and "discovery" as the guided or self-directed application of the same new concept in a variety of situations. During the exploration stage, children work with materials in an open-ended way and learn through spontaneous activities. Here, teachers ask questions or make comments only to encourage involvement. In the "invention" stage of SCIIS, the teacher presents concepts and definitions while the student looks for examples of the concept and uses the new information to interpret observations. Finally, the discovery stage offers repetition, practice, and opportunities for the student to find new applications of the concept. The phases are cyclical and frequently overlap one another. In the SCIIS Teacher's Guide each phase is clearly identified, background material is provided, and specific suggestions are given to facilitate student progression through the cycle.

According to Karplus (1971/1973), the learning cycle accommodates various theories of learning such as learning by discovery, learning by conditioning, and Piaget's learning by equilibration. Students engage in open-ended discovery, they receive direct instruction with practice, and their preconceptions are confronted with new experiences that challenge their thinking which creates disequilibrium leading to new thinking. The learning cycle promotes discussion and places the teacher in the role of a guide rather than a lecturer.

Each of the two units for each grade level is intended to be used for a semester. Each unit is divided into sections called "Parts" that contain two to six lessons. For each "Part" of the unit, the Teacher's Guide presents an overview along with student objectives. Detailed instructions are then provided for each lesson or student investigation. The lessons include set-up procedures; suggestions for managing student inquiry, collaborative groups, and discrepant events when they might occur; discussion questions; specific information to enable the teacher to "invent" concepts with the students; directions for using student manuals; suggestions for evaluation; and clean-up procedures. Extension opportunities are made available through "Extending Your Experience" cards. These and other teacher-suggested activities could be set up in learning stations to encourage further development of the discovery stage of the learning cycle.

One of the inquiry-oriented teaching strategies developed in connection with SCIS was the now familiar idea of "wait time" developed by Mary Budd Rowe, a coordinator of the SCIS trial center in New York. Eakin & Karplus report, "During classroom observations, Rowe found that the average time teachers allowed a child to begin answering a question was about one second" (1976, p. 50). Rowe's resulting studies found that lengthening "wait time" to at least five seconds increased the quantity and quality of student responses and that as "wait time" increased, teachers' questions became more flexible. She also determined that reducing verbal praise resulted in students conferring with each other rather than depending on the teacher for affirmation (Rowe, 1969/1973). This research, begun as a part of SCIS, has influenced teachers' strategies for conducting discussion in all areas of the curriculum.

SCIS includes three types of assessment for evaluating student progress: (1) concept/process evaluation, (2) attitudes in science, and (3) perception of the classroom environment. The content/process evaluation section recommends observing students as they perform unit activities; activities that are particularly suited to use for evaluation are noted. In addition, an evaluation packet of black line or spirit masters is included with the unit. Generally, students are asked to interpret diagrams or to explain experiments that pertain to major concepts and processes of the unit. The Teacher's Guide discusses a variety of student responses and offers suggestions for following up on problem areas. A class profile sheet is provided for recording observations of student curiosity, inventiveness, critical thinking, and persistence in order to assess attitudes in science. To check students' perception of the classroom environment, a form is provided that asks for an opinion of each topic studied and queries which kinds of science activity--experimenting, writing or drawing, listening to the teacher, discussing, or reading--the student prefers.

Exemplary Science Features

Science content.

The SCIS curriculum materials focus heavily on broad, overarching scientific concepts, such as systems and interactions, rather than on specific scientific areas. This emphasis is particularly evident in the physical science units, which tend to use a variety of physical science concepts to illustrate the broad concepts rather than focusing in depth on the science involved. This is somewhat less obvious on the biology side, where the broad concepts are used to illuminate the study of organisms by themselves and organisms as parts of ecosystems. In the biology half, ecological concepts such as the concepts of community and ecosystem are developed in a fair amount of depth as well as used as illustrations of the broader concepts that are the focus of the curriculum. The linkage of science to outside moral, ethical, and societal issues is not emphasized in the curriculum; neither is career education.

Science process.

SCIS is not a reading-based curriculum, but rather depends heavily on hands-on laboratory work to get its points across. The experiments are all preplanned, and there seems to be little opportunity for children to design their own experiments from scratch. Within the overall experimental design, though, there are usually opportunities for creative variation: children are allowed to choose their own arrangement for the placement of terrarium plants rather than forced to follow a preplanned planting map, and allowed to choose the site that they think best for plant growth when they place their terrarium in its final resting place in the classroom, for example. They are encouraged to follow up on the consequences of their choices: they will have to decide why their plants grew better or worse than those of a classmate who placed his terrarium in a different location, for example. The experiments thus have open-ended possibilities; it is up to the teacher to be sure that these are used to advantage, and to ensure that the effects of these variations on the final results are discussed in class. The failure of an experiment can be as illuminating as its success if the reasons for its failure are explored.

SCIS does a good job of encouraging good scientific process skills: even the youngest students keep notebooks for their data and observations, in the form of laboratory manuals. The SCIS teacher's guide encourages teachers to collect and review the notebooks periodically for assessment purposes but to refrain from writing in them or correcting them; this is an excellent idea, as a lab notebook is not a product but a tool for doing science.

Tailoring for Special Populations

Differentiation for high ability learners.

SCIS offers students the opportunity to grapple with the fundamental themes, concepts, and processes of science such as interaction, matter, energy, system, reference object, and scientific theory. This organization of content according to broad themes encourages a high level of thought and avoids the rote memorization of facts that characterize many elementary science curricula. Because the curriculum provides a range of experiences from concrete to abstract along with a solid information base, SCIS accommodates high ability learners to some extent.

However, the accommodation of high ability learners by SCIS is implicit rather than explicit. The extensions that are provided are only partially sufficient. It is left up to the teacher to add bibliographies and multiple resources for extended content exploration and indepth investigations. In addition, it is left up to students and teachers to develop projects that utilize the entire process of experimental design from hypothesis-building to oral and written reporting.

Other special populations.

The earlier SCIS program was considered to be particularly effective in improving the oral language of urban and disadvantaged children (Rowe, 1968/1973 & Codispoti, 1969/1973). Children eagerly described their science experiences and responded to the questioning techniques of teachers trained by SCIS developers. The revised SCIS program has retained these rich oral and written language opportunities.

The SCIS curriculum avoids racial and gender stereotyping. The opportunities it provides for open inquiry and for collaborative work may encourage girls and minority students to participate in science.

CONCLUSION

SCIS is one of the landmark science curricula that emerged during the 1960s. Some of the strategies and theories of science teaching developed for the program such as the learning cycle and "wait time" in classroom discussions have subsequently influenced all areas of curriculum of development. In addition, SCIS is unique in its focus on students working with live organisms in a sequenced program from kindergarten to sixth grade.

The initial exploratory phase of the SCIS learning cycle is a strong feature of the program that promotes authentic scientific inquiry. The open-ended character of the hands-on activities promotes critical thinking and scientific process skills. The program incorporates a balance of substantive science content with process skills and attitude development.

Because SCIS accommodates various levels of students' cognitive development within each activity, it meets the needs of a wide range of students. However, in order to fully meet the needs of high ability learners, teachers must adapt the curriculum by adding components such as multiple resources and independent investigations.

REFERENCES

- Atwood, R. K., & Howard, M. N. (1990). SCIS-II and the elementary teacher: A program evaluation. Journal of Research in Science Teaching, 27, 849-859.
- Bredderman, T. (1983). Effects of activity-based elementary science on student outcomes: A quantitative synthesis. Review of Educational Research, 53(4), 499-518.
- Codispoti, R. T. (1973). SCIS and the urban community. In SCIS Omnibus (pp. 109-110). Berkeley, CA: University of California, Lawrence Hall of Science, Science Curriculum Improvement Study. (Reprinted from SCIS Newsletter, Summer 1969, 15)
- Eakin, J. R., & Karplus, R. (1976). SCIS Final Report. Berkeley, CA: University of California, Lawrence Hall of Science, Science Curriculum Improvement Study.
- Karplus, R. (1973). Three guidelines for elementary school science. In SCIS Omnibus (pp 126-127). Berkeley, CA: University of California, Lawrence Hall of Science, Science Curriculum Improvement Study. (Reprinted from SCIS Newsletter, Spring 1971, 20)
- Rowe, M. B. (1973). Science, silence, and sanctions. In SCIS Omnibus. (pp. 106-108). Berkeley, CA: University of California, Lawrence Hall of Science, Science Curriculum Improvement Study. (Reprinted from Science and Children, March 1969)
- Shymansky, J.A. (1989, April). What research says about ESS, SCIS, and SAPA. Science and Children, pp. 33-35.
- Shymansky, J.A., Hedges, L.V., Woodward, G. (1990). A reassessment of the effects of inquiry-based science curricula of the 60's on student performance. Journal of Research in Science Teaching, 27, 127-144.
- Shymansky, J.A, Kyle, W.C., and Alport, J.M. (1982, November/December). How effective were the hands-on science programs of yesterday? Science and Children, pp. 14-15.
- Shymansky, J.A., Kyle, W.C., and Alport, J.M. (1983). The effects of new science curricula on student performance. Journal of Research in Science Teaching, 20, 387-404.

Curriculum Evaluation Form**Science Curriculum Improvement Study (SCIS)****Phase I Review**

<u>Curriculum Design</u>	<table border="1"><tr><td>3</td><td>2</td><td>1</td></tr></table>	3	2	1	Average Rating
3	2	1			
Reviewer #1	3.00	3.00			
Reviewer #2	3.00	(Scale 1-3)			

<u>Classroom Design</u>	<table border="1"><tr><td>3</td><td>2</td><td>1</td></tr></table>	3	2	1	Average Rating
3	2	1			
Reviewer #1	2.80	2.76			
Reviewer #2	2.71	(Scale 1-3)			

<u>Technology</u>	<table border="1"><tr><td>3</td><td>2</td><td>1</td></tr></table>	3	2	1	Average Rating
3	2	1			
Reviewer #1	NA	NA			
Reviewer #2	NA				

Phase II Review

<u>Science Content</u>	<table><tr><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr></table>	5	4	3	2	1	Average Rating
5	4	3	2	1			
Reviewer #1	3.67	3.80					
Reviewer #2	3.92	(Scale 1-5)					

<u>Science Process</u>	<table><tr><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr></table>	5	4	3	2	1	Average Rating
5	4	3	2	1			
Reviewer #1	4.72	4.15					
Reviewer #2	3.57	(Scale 1-5)					

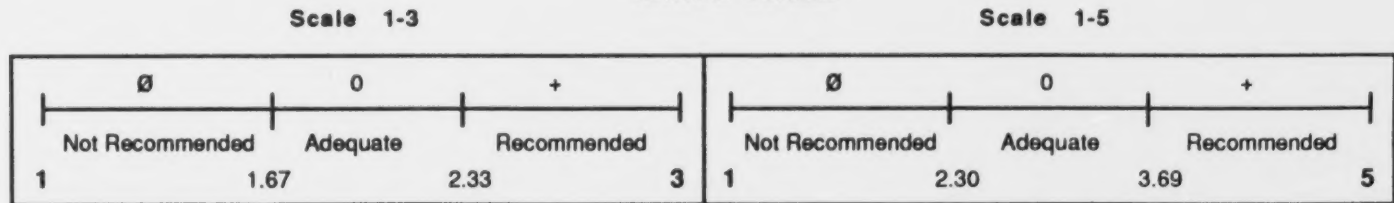
Phase III Review

<u>High Ability Learners</u>	<table><tr><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr></table>	5	4	3	2	1	Average Rating
5	4	3	2	1			
Reviewer #1	3.25	3.20					
Reviewer #3	3.15	(Scale 1-5)					

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Science Curriculum Improvement Study (SCIIS)	3.0 +	2.76 +	NA	3.80 +	4.15 +	3.20 O	

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Silver Burdett & Ginn Elementary Science
 Silver Burdett & Ginn, 1989
 160 Gould Street
 Needham Heights, MA 02194-2310
 (617) 455-1850/1853

Grades K-6

OVERVIEW

Description

The Silver Burdett & Ginn Elementary Science curriculum is a basal text series that develops four content strands from kindergarten to grade six. The four strands are: life science, physical science, earth science, and the human body. The life science strand includes plants, animals, and ecology; physical science includes matter and energy; earth science encompasses earth, space, and weather. In addition to information about body systems, the human body strand includes health and safety.

Student texts and teacher manuals deliver the core program with numerous materials available to supplement it. First, a teacher's resource file includes copy masters for each chapter of the textbook, test copy masters, a Science Olympics activities booklet designed "to challenge the academically talented student," Invention Convention information, bulletin board posters, health copy masters, parent's letters in Spanish, a student workbook teacher's edition, color overhead transparencies, and a guide for helping students to achieve English proficiency with the program. Other materials include laboratory equipment packages, learning center labs, sound filmstrips, big book/picture packets, and computer courseware. Inservice video tapes for teachers can be purchased for each grade level.

Major Program Goals

Major curriculum goals and objectives are not stated; instead specific objectives are given for each lesson. Thus, topical scope and sequence charts rather than goals and objectives provide the curriculum structure. The objectives typically address comprehension of content. For instance, the chapter "Building Blocks of Matter" in the fifth grade curriculum is based on the following objectives:

- Describe ways in which scientists study matter.
- Describe the parts of an atom.
- Discuss the relationship between atoms and elements.
- Give examples of symbols used to represent elements.
- Compare elements, compounds, and molecules.
- Give examples of compounds.
- Differentiate between an element and a compound.
- Differentiate between an element, a molecule, and a compound.

Research Evidence of Effectiveness

No research evidence is available for the effectiveness of Silver Burdett & Ginn Elementary Science. Rather, the publishers conducted field testing or market research during the developmental stages of the series. Market research includes surveying the literature of

educational research and educational reform movements to determine current trends. In addition, teachers are polled and students interviewed in order to improve the product. Summaries of the field testing or market research are then made available to textbook adoption committees in various forms such as "Learner Verification" reports.

ANALYSIS

General Curricular Features

Curriculum design.

The rationale of the series is expressed in an opening declaration of the teacher's manual: "Silver Burdett & Ginn Science is organized for success...covering the content you like to teach at your grade level." The series attempts comprehensive coverage of all science topics that might interest teachers. In fact, a chart in the teacher's guide alerts teachers to the lessons that are necessary for minimal coverage of a content strand and recommends that the other lessons be used if time permits. In the grade five chapter on animals without a backbone, the lessons on classifying living things, worms, and animals with jointed legs are listed as essential; sponges, animals with stinging cells, animals with spiny skin, and animals with a soft body are less important according to the chart.

Each chapter includes examples of the scientific technology or application of the topic under study. Frequently, this information is found in "Science and Technology" boxes scattered throughout the text. Likewise, information about related careers and biographical information about scientists is highlighted in boxed features.

Many of the activities which are interspersed throughout the student text require only observation and the answering of questions. In the fifth grade, for instance, students observe a fish in a jar that contains water, measure and record the temperature of the water, and then count and record the number of times the fish opens and closes its mouth in one minute. After adding ice cubes to the water, students again measure and record the temperature as well as count and record the fish's mouth movements. They are then asked how the water temperature affects the speed of a fish's breathing. The program lacks in-depth, inquiry-based student investigation of scientific questions and problems.

Classroom implementation.

Silver Burdett and Ginn Science lesson plans consist of various components that are designed to satisfy the universal requirements of teachers and administrators. Each lesson contains clearly stated objectives, content material amply illustrated with photographs and diagrams, and step-by-step student activities. Following the format of many basal science texts, the hands-on activities are so fully described within the student text that they become nonessential. It is possible for students to simply read about the science process skills of observing, classifying, communicating, measuring, hypothesizing, predicting, and drawing conclusions.

As a text-based science program, Silver Burdett and Ginn Science depends on reading comprehension. Words are defined before students have experiences with the concepts which are being studied. Also, the series makes no attempt to assist teachers in identifying and

countering students' misconceptions or naive theories about science. Therefore, it is possible for students to "speak the language" of science but not understand what they are saying.

Questions to stimulate student thinking and to help teachers lead discussion are scattered throughout the student text and teacher's manual. Questions for each lesson that are based on Bloom's Taxonomy are found in the teachers' manual. In the student text, the lesson review provides a vocabulary quiz, short-answer questions, and a few questions designed to initiate research. However, a "Study Guide" which is isolated at the back of the book where it can be overlooked contains excellent questions to probe student understanding. For each chapter the study guide includes questions based on reading the text, challenging problem solving questions, and skills questions that require reading tables and graphs.

The assessment measures provided in the program consist of copy masters called "Chapter Checkups," "Chapter Tests," and "Unit Tests" in a standardized test format. The series authors claim that teachers can use the lesson-opening question for instant pre-post assessment to determine previous knowledge and to evaluate growth in understanding at the end of the lesson.

Technology.

Ancillary computer software is available for the Silver Burdett and Ginn Science series, but it was not evaluated for this review. The software includes: (1) "ScienceWorks" computer courseware for grades three through six which provides simulation activities, (2) courseware for grades three to six that provides vocabulary reinforcement, and (3) "MicroManager" software that provides computerized assistance in scoring tests and generating reports.

Exemplary Science Features

Science content.

Used as a reference, Silver Burdett & Ginn Science does a good job of presenting science content in a clear, understandable way. The science is generally accurate and usually presented in enough detail for reasonable understanding of the topic. However, detail is not included simply for its own sake; extraneous information unnecessary for understanding the concepts is minimal. This series mentions many topics at each grade level, rather than covering a few topics in great depth; however, the explanations are clear enough to result in a useful resource.

Science process.

The number of activities in which the student can experience aspects of the scientific process is relatively limited in this series, at least when compared with an activity-based curriculum. Many of the labs presented are verification exercises. Still, many of the labs are worthwhile; many of them will contribute substantially to the students' understanding of the topics discussed in the text. It is important for a large number of the available activities to be used by the teacher; otherwise, the scientific process component of the curriculum will be too limited.

Tailoring for Special Populations

Differentiation for high-ability learners.

Although the publisher does a clear job of articulating the importance of higher order thinking skills and concept development, the implementation of these issues for high-ability learners is not well developed. Because the textbook and accompanying workbook provide the main curriculum delivery system, the incorporation of inquiry-based instructional techniques depends on the teacher's ability and initiative.

Two types of differentiation for high-ability learners are provided within the teacher's materials. First, each chapter includes a list of "Gold Medal Words" such as those in the "Cleaning Up the Earth" fifth grade chapter: immaculate, antiseptic, sterile, disinfected, pristine, impeccable, pure, hygienic, uncontaminated, and spotless. Students are asked to find out about the words and to use the words to list examples of things that are clean. Obviously, overuse of the "Gold Medal Words" could kill an emerging interest in science or cause a student to repress innate abilities. Also, vocabulary development and use is good for a language arts connection to science but does not enhance appropriate science learning for high ability students.

The second differentiation technique offered teachers consists of the "Science Olympics" booklet at each grade level which "focuses on the special needs and abilities of students whose academic performance on standardized tests places them in the top 20 percent of the population nationally." The booklet includes copymasters and suggestions for activities that are intended to promote problem solving and independent learning. Many of the activities would result in meaningless student reports and student-made bulletin boards.

Other special populations.

The series publishers acknowledge a wide potential audience in several ways. Each chapter of the teacher's manual offers suggestions for mainstreaming handicapped and disabled students. Illustrations in the student texts show both girls and boys conducting science experiments. In addition, diverse ethnic and cultural groups are represented in the biographical profiles of people working in the field of science.

CONCLUSION

Silver Burdett and Ginn Science attempts to meet all the science curriculum needs of the nation's schools. Although it succeeds in delivering a comprehensive coverage of science topics, it does not ensure that students will experience and understand broad science concepts. For instance, the student activities found in the text and the workbook frequently serve as demonstrations to illustrate presented content rather than as open-ended opportunities for students to discover principles or to formulate their own questions. Although the teacher's and administrator's guide recommends using more than paper and pencil testing, the explicit evaluation procedures that are provided consist of tests of vocabulary and the comprehension of main ideas.

This curriculum must be radically adapted and modified by the teacher before it can meet the needs of high-ability learners. Necessary adaptations include pre-testing to determine what students already know and subsequent compression of content and opportunities for acceleration. In addition, the enrichment opportunities provided to high-ability learners should include more emphasis on sophisticated content and research such as problem generation, problem solving, and interdisciplinary connections rather than emphasizing only report writing and vocabulary building.

Curriculum Evaluation FormSilver Burdett & Ginn Elementary Science
Phase I ReviewCurriculum Design

3	2	1
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Average Rating

Reviewer #1

2.36

2.36
(Scale 1-3)Classroom Design

3	2	1
---	---	---

Average Rating

Reviewer #1

2.30

2.30
(Scale 1-3)Technology

3	2	1
---	---	---

Average Rating

Reviewer #1

NA

NA

Phase II ReviewScience Content

5	4	3	2	1
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Average Rating

Reviewer #1

2.11

3.50

Reviewer #2

4.88

(Scale 1-5)

Science Process

5	4	3	2	1
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Average Rating

Reviewer #1

1.66

2.46

Reviewer #2

3.25

(Scale 1-5)

Phase III ReviewHigh Ability Learners

5	4	3	2	1
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Average Rating

Reviewer #1

1.50

1.90

Reviewer #3

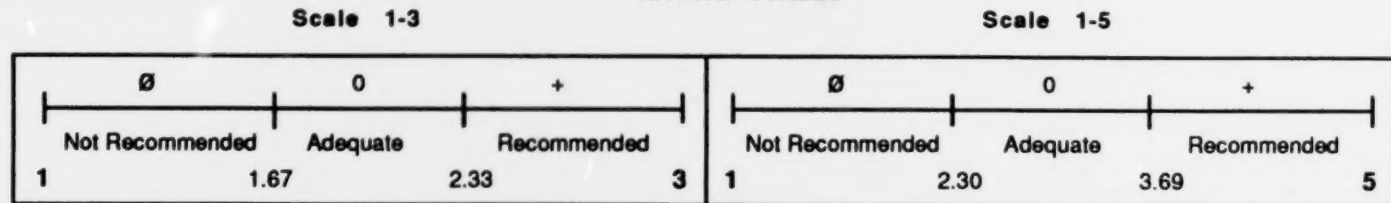
2.30

(Scale 1-5)

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Silver Burdett & Ginn Elementary Science	2.36 +	2.30 O	NA	3.50 O	2.46 O	1.90 Ø	

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Windows on Science
Optical Data Corporation
30 TEchnology Drive
Warren, NJ 07059
1990

Grades 1-6

OVERVIEW

Description

Windows on Science is a curriculum that replaces textbooks with a videodisc presentation of science material. The videodiscs are large silver platters the size of phonograph records that store up to 54,000 still images or several hours of motion pictures. These images serve as the heart of the curriculum. They are played on a videodisc player which is similar to a CD player and is attached to a video monitor. The random access design of the videodisc allows frames to be accessed instantaneously via a reference number rather than by passing through all intermediate frames. For example, audio portions in Windows on Science occur in the movie segments and can be played in English, Spanish, or both languages through stereo speakers. No audio accompanies the still frames.

Eleven discs are included in the series. "Primary Science" is contained on three discs for grades 1-3. Upper elementary and middle grade materials are contained on 8 more discs: "Earth Science" and "Physical Science" are each on three discs; "Life Science" is on two. Each disk is accompanied by three books. First, a Resources book for teachers includes detailed "scripts" for use with the discs, activity masters, and tests. Second, a Lesson Manager binder contains a list of all visual frames by number and by category description. The third book contains a tutorial for teachers and a reference guide that describes the underlying design of the curriculum.

Print resources for students are included in the form of pamphlets that are keyed to lessons about third grade.

Major Program Goals

The following goal of Windows on Science is stated in the Curriculum and Instruction section of the reference guide:

To prepare students to participate in making decisions which will affect their lives.

No other overarching goals or objectives for the program are stated.

Research Evidence of Effectiveness

No research evidence is available for the effectiveness of Windows on Science. Rather, the publishers conducted field testing or market research during the development stages of the series. Market research includes surveying the literature of educational research and educational reform movements to determine current trends. In addition, teachers are polled and students interviewed in order to improve the product. Summaries of the field testing or market research are then made available to textbook adoption committees in various forms such as

"Learner Verification" reports. Optical Data has cited research that suggests possible benefits of videodisc technology in motivation, attitudes, and achievement of students in various learning situations, but an evaluation of the Windows on Science program has not been done.

ANALYSIS

General Curricular Features

Curriculum design.

Earth, life, and physical sciences are the stated themes for this curriculum but no formal scope or sequence is provided. Most of the content takes the form of grade appropriate topics such as work and machines, earth's weather, and so on. However, the discs can also be used to design a customized curriculum by selecting and sequencing visuals as desired.

The curriculum is based on a learning model called the Circle of Learning. It begins with *seeing and hearing*, moves to *discussing*, then *doing, questioning, reading, writing, visualizing*, and back again to *seeing*.

The video presentation is exciting and makes science appear meaningful to students. The teacher sets the pace of the lesson by using the video player remote controller. Narration must be provided by the teacher during the still frame portions of the presentation. Students interact with the visuals and the teacher by way of teacher-directed discussion. There are some occasional uses of the videodisc for scientific purposes such as an activity that tests response time by having students push the remote control to stop the motion of the video frames.

Other activities are usually worksheet driven. Some hands-on activities that reinforce the video content are also included but are usually verification experiments rather than open-ended inquiry. To its credit, the program is designed to avoid the "read first" approach where the stage is set with written text. Nonfiction readings are provided for selected lessons for use after exposure to material on the videodisc.

Classroom implementation.

The teacher plays a central role in the delivery of the Windows on Science curriculum. The teacher's Resource book provides a detailed model script to accompany the video presentation but the skillful teacher can develop his/her own lesson plans around the visuals. In fact, the teacher should be able to comment and generate questions without reading the script to avoid monotonous tone that would be encountered in a pre-recorded movie. Background information for the teacher is included in the lesson materials but it is not structured for the classroom. Without some expertise the teacher could be reduced to a passive videodisc operator.

The pacing of the material can be adjusted by skipping over material that students already know. Likewise, review or re-teaching can be done quickly by selecting frames that are appropriate. However, the whole class is required to view the same presentation during a class session. It might be wise to teach notetaking to students since they have little written material to use for review. At grade levels 3 and above some vocabulary words are listed in the ancillary reading pamphlets. A basal text might also be used in conjunction with this program as an additional resource.

Most activities are teacher directed and rely on worksheets. Convergent questions are dominant in the activities. The teacher can alter this trend by striving for more divergent thinking in discussions; this, however, is entirely dependent on the desire and skills of the teacher. There is little material that is open-ended or highly integrated with other academic disciplines. The connections to mathematics are not strong and should be emphasized and supplemented by the teacher.

Many of the tests that are included are objective, using true-false, fill in, matching, and multiple choice items. Other assessment ideas are suggested but "authentic" assessment is difficult as few opportunities for real scientific products are available.

Extension and enrichment ideas are presented on a single page at the beginning of each unit. Since they are not tied directly to the lessons where they would be best used, teachers might forget they're there. Most are routine extension activities without an open-ended design.

Workshops for teachers are available from Optical Data. It would be advisable for users of Windows on Science to be well trained before embarking on this teaching adventure. There could be problems if the teacher is absent as it would be difficult for a substitute teacher to teach these video-based lessons without previous experience with the program. The teacher will also have to find a way to allow students who have been absent to view missed lessons.

Technology.

The videodisc technology used in Windows on Science is effective in capturing the interest of students. The images are impressive and informative. The old adage, "One picture is worth a thousand words," may hold for a number of students who are poor readers, but can understand information presented in the video format.

The visual emphasis of this program makes adventures possible that could not have been experienced in the actual classroom. The program includes viewing of natural phenomena such as tornadoes and volcanoes. Students can make close observations planets and sea creatures. The speed of the movies can be adjusted for slow motion observation. A reservoir of supplemental video frames is included on the discs and can be used as a visual resource for student reports.

This technology is a powerful tool for teaching as long as it is not treated merely as a glorified slide show.

Exemplary Science Features

Science content.

The video discs allow teachers and students to visualize important scientific concepts. The content is not deep or open-ended. It is designed to cover basic knowledge about science.

Science process.

The activities portion of the curriculum does not feature hands-on approach to actually doing science. In the primary grades, worksheets with crayons and pencils are commonly used

activity materials. Few opportunities for hypothesis testing, lab or field work, or interaction with scientists are included.

Tailoring for Special Populations

Differentiation for high ability learners.

This curriculum contains special features that benefit low ability readers and native speakers of Spanish. However, it does not tend to favor high ability learners. A high level of challenge is not naturally built into the curriculum. The objectives, activities, and assessments are heavily weighted toward lower level thinking skills. Even the few objectives that appear to demand performance at the analysis level fail to be evaluated at that level of assessment. For example, in "Life Science" an objective states that "students will be able to compare asexual and sexual reproduction" at the end of the unit. But no comparison is asked of the students in the assessment items. The test questions are all objective and require no higher level thinking skills.

The activities do not contain enough open-ended problems, inter-disciplinary connections (including challenging reading and writing opportunities), or opportunities to develop advanced products for high ability learners. Some of the extension ideas, however, are promising. For example, in the unit called "Body Inside Out" students are asked to speculate on whether the appendix will eventually disappear in the evolutionary process and what additions to the body may be needed in the future. There are not enough of this kind of activity.

The pacing of presentation material could be a problem for high ability learners. In a heterogeneously grouped class the pace might be too slow and it would be difficult to make provisions for faster learners. There is a danger that the best students would be used as tutors for students who have been absent. Or if the teacher does a review for slower learners or for students who have missed a lesson, it could be very boring for those who don't need it. Even with a homogeneous high ability class where the pace could easily be accelerated, some supplementing would be in order so that the level of challenge would be appropriate for these students.

Other special populations.

This curriculum shows no special features that are particularly advantageous to girls or disabled students. Native speakers of Spanish might find the bilingual options helpful if they are not adept in English.

CONCLUSION

The strength of Windows on Science is its attractive presentation. It teaches basic science but does not delve deeply into content or scientific process. Students learn about science, but 'learning by doing' is not a focus of the curriculum. It is an appealing program for nonscience prone students; the visual representation could be instrumental in sparking further interest.

In some respects the videodisc format is subject to many of the problems that tend to occur with basal textbooks. Changing the mode of presentation of basic material does not address the problem of providing appropriate science instruction for high ability or gifted learners. If this program were used as a supplement to another process-oriented program with more in-depth content and complex concepts, it could be advantageous for gifted learners.

Curriculum Evaluation Form**Windows on Science****Phase I Review****Curriculum Design**

3	2	1
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Average Rating

Reviewer #1

2.34

2.25

Reviewer #3

2.15

(Scale 1-3)

Classroom Design

3	2	1
---	---	---

Average Rating

Reviewer #1

1.99

1.88

Reviewer #3

1.76

(Scale 1-3)

Technology

3	2	1
---	---	---

Average Rating

Reviewer #1

2.46

2.42

Reviewer #3

2.38

(Scale 1-3)

Phase II Review**Science Content**

5	4	3	2	1
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Average Rating

Reviewer #1

2.50

2.38

Reviewer #2

2.25

(Scale 1-5)

Science Process

5	4	3	2	1
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Average Rating

Reviewer #1

2.71

2.07

Reviewer #2

1.43

(Scale 1-5)

Phase III Review**High Ability Learners**

5	4	3	2	1
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Average Rating

Reviewer #1

2.33

2.08

Reviewer #3

1.83

(Scale 1-5)

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Windows on Science	2.25	1.88	2.42	2.38	2.07	2.08	
	0	0	+	0	0	0	

RATING SCALES

Scale 1-3				Scale 1-5			
0 0 + Not Recommended Adequate Recommended 1 1.67 2.33 3				0 0 + Not Recommended Adequate Recommended 1 2.30 3.69 5			

Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Section III Modular Programs

Modular curricula are packaged in independent units that are organized around large topics or concepts. They include elements of well designed curriculum such as objectives, activities, sequence of content, and assessment measures. The modules may be used in two ways: a) the units may be chosen to design a customized, full-year curriculum or b) individual units may be selected to enrich or replace portions of existing curriculum. Many curricula which are considered "cutting edge" are among these reviews; unlike the comprehensive/stand-alone series, they tend to be developed and/or distributed through the support of scientific organizations such as National Geographic (Kids Network), the Smithsonian Institution (Science and Technology for Children), and Lawrence Hall of Science (GEMS, CEPUP).

List of Modular Programs Reviewed

Chemical Education for Public Understanding (CEPUP)

Elementary Science Study (ESS)

Full Option Science System (FOSS)

Great Explorations in Math and Science (GEMS)

Insights

National Geographic Kids Network

Science and Technology for Children (STC)

Grades 7-9**Chemical Education for Public Understanding Program (CEPUP)**

Developed by Lawrence Hall of Science, University of California at Berkeley

Distributed by Addison-Wesley (Menlo Park, CA)

1990-to date

OVERVIEW**Description**

The CEPUP--Chemical Education for Public Understanding Program integrates chemical concepts and processes with societal issues through inquiry-based activities that emphasize problem solving and decision making. The program is designed to be used in schools and in community education programs. Currently, six modules comprise the program: "Chemical Survey & Solutions and Pollution," "Determining Threshold Limits," "Risk Comparison," "Investigating Groundwater: the Fruitvale Story," "Toxic Waste: A Teaching Simulation," and "Plastics In Our Lives." The modules are briefly summarized as follows:

"Chemical Survey and Solutions and Pollution" consists of two units presented in one module. In "Chemical Survey" students survey their knowledge and attitudes about chemicals, then analyze and interpret the data before writing a report. In "Solutions and Pollution," they consider water as a universal solvent and explore dilution and neutralization as possible answers to water pollution.

In the "Risk Comparison" unit, students explore chance and probability in mathematics and are introduced to the concept of risk in their lives. They use the historical data of smallpox and cholera research to discuss epidemiology and risk taking in order to gain insight to their own decision making.

"Determining Threshold Limits" presents concepts of thresholds, qualitative research, and quantitative research through analysis of solutions and controlled experiments. Students consider toxicity and "how safe is safe?"

"Investigating Groundwater: the Fruitvale Story" offers students the opportunity to understand the concepts of aquifer and aquitard by measuring the length of time it takes water to move through various earth materials. Through simulations, inquiry, and role playing; students study groundwater, test wells for a pesticide, draw boundaries of safe concentration levels, compare various interpretations of results and consider the uncertainty in sampling testing.

In "Toxic Waste: A Teaching Simulation" students consider the problem of disposing of a toxic heavy metal that cannot be reclaimed. The unit presents experiences with several alternative treatment processes such as dilution, reclamation, producing and filtering precipitates, and solidification and stabilization. Students review the various processes for handling the toxic waste and compare the advantages and disadvantages of each method.

"Plastics In Our Lives" requires decision-making based on practical versus ideal criteria. Students examine the properties of four common plastics, and compare the advantages and disadvantages of synthetic and natural polymers.

Four CEPUP modules are being developed at this time: "Investigating Chemical Processes: Your Island Factory," "Chemicals in Food: Additives," "The Waste Hierarchy," and "Experiencing Scientific Research: An Air Pollution Study."

Designed for nonlaboratory settings, the CEPUP materials consist of a teacher's manual and a kit. The teacher's manual includes: (1) a conceptual overview, (2) an activity overview, (3) detailed lesson plans for each activity, (4) student worksheets, and (5) a student evaluation. The kit with materials for five classes includes CEPUP trays (a package of nine small test tubes and five beakers) along with solutions, solid reagents, and specialty items. The CEPUP experiments can be conducted in classrooms without sinks by using containers of water and buckets to collect waste.

Major Program Goals

Overall goals of the CEPUP program are listed as follows:

- To provide educational experiences focusing on chemicals and their interaction with people and the environment.
- To promote the use of scientific principles, processes, and evidence in public decision making.
- To contribute to improving the quality of science education in America.

Research Evidence of Effectiveness

At the time of this review, the developers of CEPUP are concluding a major evaluation study conducted under the leadership of Peter Kelly, Professor and Dean of the School of Education at Southampton University, England. Schools taking part in the evaluation were located in rural Michigan and Monterey, San Bernadino and San Diego counties in California. The study is evaluating the extent to which each of the CEPUP program goals were attained. The introduction to the working draft (Kelly, 1991) of the report states:

This report is focussed on three studies, each revealing a different perspective of the impact of CEPUP in schools. One study is concerned with teachers' perceptions of the impact on the teaching and other activities, another looks at students' attitudes and opinions concerned with key issues covered in the CEPUP modules, and the third assesses the students' performance on the achievement tests of each of the modules. (p. i)

Overall, the report concluded that CEPUP goals had been achieved in positive and significant ways. For instance, there were changes in class activities that reflected the intentions of the CEPUP program, and students perceived the changes as helpful. During CEPUP study, students' opinions of chemicals changed in that they perceived chemicals as more important, necessary, interesting, helpful, and less dangerous. Students also gained stronger convictions that individuals can play a major part in dealing with pollution problems and that decisions concerning pollution are best made collectively by people with different view points. The results of the achievement tests indicated that a majority of students acquired an understanding of basic science, science process, and social issues as interpreted in the CEPUP modules.

ANALYSIS

General Curricular Features

Curriculum design.

Each module begins with a conceptual overview chart that lists chemistry concepts, process concepts, and societal issue concepts. The following chart presents three of the six sets of concepts from the "Investigating Groundwater: The Fruitvale Story" unit.

<u>Science Concepts</u>	<u>Processes</u>	<u>Societal Issues</u>
Dilution, concentration and serial dilution. Parts per million (ppm)	Use ratio comparison and percent concentration Observe and infer.	How can we make informed decisions based on evidence we cannot directly experience?
Behavior of chemicals in solution. Toxicity of chemical.	Identify key information to develop and use hypotheses.	Decision-making based on evidence and the use of reasonable inferences.
Pollutant concentration.	Perform simulated testing of pollutant levels in well samples. Revise hypotheses. Revise hypotheses.	What are the limits of scientific knowledge? What are the limits on research imposed by technical and economic resources?

The CEPUP program capitalizes on the emerging independence of middle school students and their need to become informed decision makers. By offering students concrete experiences linked with opportunities to make inferences and decisions, the program developers endeavor to foster the transition from concrete to abstract thinking that is necessary at this age level. In addition, the integration of science concepts, scientific process/inquiry skills, and societal issues results in a program that contributes to the interdisciplinary curriculum of middle schools.

Classroom implementation.

The clearly written and well-organized manuals provide teachers with rationale; background material, integrated content, process, and issues; and engaging activities. The manuals offer guidelines for conducting discussions including specific questions. Likewise, the manuals provide recording forms and guide sheets for students to use when conducting experiments. A glossary of terms concludes the manual.

Each unit is supported by three to six activities which are designed to be completed in one or two class periods of forty or fifty minutes. The activities allow students to work in pairs and groups of four as well as in a large group. The activities range from seeking evidence through reading and discussion to hands-on investigations. For instance, an historical account of smallpox inoculation and immunization provide the context for studying risk factors; whereas performing a serial dilution of food coloring enables students to understand concentration levels of parts per

million. Some activities include role playing. Optional activities that rely on mathematical and chemical formulas provide flexibility for adapting and modifying the program. Unfortunately, the manuals do not recommend resources or activities that could be used for independent inquiry and extended learning.

An achievement test with both multiple choice and short answer questions is included in the manual. The test questions vary to include recall, diagrams that must be analyzed and interpreted, questions that ask for evidence, and questions that require students to develop brief plans. The array of questions allows teachers to assess student understanding on several levels.

Technology.

CEPUP does not utilize technology such as computers and video in its instructional program. However, it explores issues that are the result of the use of technology in our society.

Exemplary Science Features

Science content.

CEPUP is not a comprehensive science program; rather it is a supplementary program that integrates societal issues of chemistry with content and process. The content of CEPUP is based on what people need to know to make informed decisions. For instance, the content in the Risk Comparison module centers on probability, chance, risk analysis and comparison, voluntary and involuntary risks, and the assessment of risk. Epidemiology, smallpox, and cholera serve as examples to study the subject of risk.

The content that CEPUP addresses is important and covered in depth. It is a unique program in that it offers students the opportunity to experience the decision-making process required of conscientious adults in our society. Because CEPUP focuses on evidence rather than advocacy (Thier, 1990), the modules present science as tentative, asking questions and presenting all sides of the issue. In this program, students experience ambiguous issues, discuss them, encounter diverse opinions, and reach their own conclusions. CEPUP transforms abstract concepts into concrete experiences.

Science process.

The hands-on experiments in CEPUP are integral to the program. Intended for classrooms, not laboratories, the experiments are simple and designed to build concepts. For instance, in the Determining Threshold Limits module students taste drops of salt water of known concentrations to determine their threshold of taste for salt. Later in the module, students observe characteristic properties of selected chemicals and then use the properties to identify an unknown chemical. Within the module, students use both qualitative analysis to identify an unknown chemical and quantitative analysis to determine concentration of an unknown solution.

Tailoring for Special Populations

Differentiation for high ability learners.

CEPUP offers gifted learners and their teachers excellent source material for developing

problem-based learning. The CEPUP program presents experiences with the problems and uncertainties of "real" science, and it demonstrates the allure of scientific discovery. The program can serve as a catalyst for exploring issues, extending student research, and providing rich interdisciplinary experiences. However, it is up to the teacher to find extension materials and to add the depth necessary high ability learners.

Other special populations.

Although CEPUP does not specifically address the needs of special populations, features of the program meet the learning needs of girls and minority students. In particular, the variety of teaching strategies which include hand-on activities, discussion, attention to diverse opinions, and cooperative learning accommodate the needs of girls and minority students. The integration of societal issues makes science important to all students, especially those who may need to be introduced to the relevance of science in daily life.

CONCLUSION

The Chemical Education for Public Understanding Program is an imaginative, carefully developed curriculum that is intended to have broad application for general education. The strength of this curriculum is the integration of science concepts, scientific process, and societal issues. Students have the opportunity to practice decision making in important scientific contexts.

For high ability students, the program offers a tantalizing introduction to issues and concepts but does not explore them in sufficient depth. To challenge gifted learners, teachers must add resources and activities that explore more complex concepts.

REFERENCES

- Kelly, P. (1991). Perceptions and Performance: An Impact Assessment of CEPUP in Schools. Unpublished manuscript, University of California at Berkeley, Lawrence Hall of Science, CEPUP.
- Thier, H. D. (1990). "Evidence or advocacy: the role of science education." The CEPUP Quarterly, 2, 4.

Curriculum Evaluation FormCEPUPPhase I ReviewCurriculum Design

3 2 1

Average Rating

Reviewer #1

2.93

2.93
(Scale 1-3)Classroom Design

3 2 1

Average Rating

Reviewer #1

2.49

2.49
(Scale 1-3)Technology

3 2 1

Average Rating

Reviewer #1

NA

NA

Phase II ReviewScience Content

5 4 3 2 1

Average Rating

Reviewer #1

4.11

4.33

Reviewer #2

4.55

(Scale 1-5)

Science Process

5 4 3 2 1

Average Rating

Reviewer #1

4.00

4.00

Reviewer #2

4.00

(Scale 1-5)

Phase III ReviewHigh Ability Learners

5 4 3 2 1

Average Rating

Reviewer #1

3.08

3.74

Reviewer #3

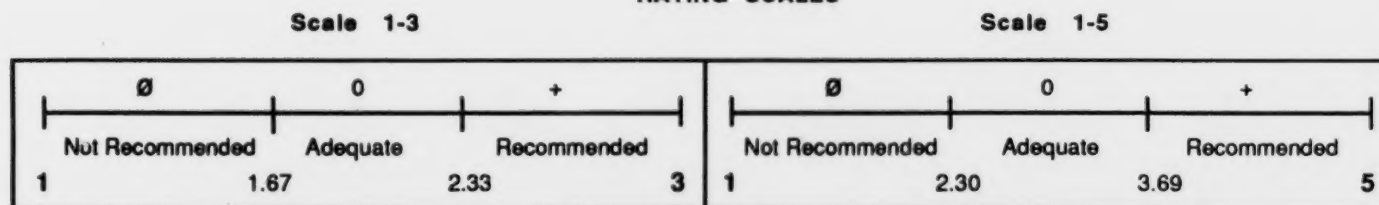
4.40

(Scale 1-5)

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Chemical Education for Public Understanding (CEPUP)	2.93 +	2.49 +	NA	4.33 +	4.00 +	3.74 +	A, B, C, D

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Elementary Science Study (ESS)**Grades K-9**

Developed by Education Development Center, Inc., Newton, MA 02160

Trial and original editions available from ERIC

Commercial modules distributed by:

Delta Education, Inc.

P. O. Box M

Nashua, NH 03061-6012

(800) 258-1302

OVERVIEW**Description**

Elementary Science Study (ESS) is one of the hands-on elementary science projects that was funded by the National Science Foundation during the 1960s and early 1970s. ESS focuses on putting materials into students' hands and then helping students use the materials to investigate and discover.

The units which are currently available from Delta Education, Inc. include:

Ant Farm	Microgardening
Attribute Games and Problems	Mobiles
Balloons and Gases	Multipurpose Balance
Batteries and Bulbs	Mystery Bones
Behavior of Mealworms	Mystery Powders
Brine Shrimp	Optics
Butterfly Garden	Pattern Blocks
Clay Boats	Peas and Particles
Colored Solutions	Pendulums
Drops, Streams and Containers	Primary Balancing
Earthworms	Rocks and Charts
Eggs and Tadpoles	Senior Balancing
Gasses and "Airs"	Sink or Float
Geoblocks	Small Things
Growing Crystal Gardens	Spinning Tables
Growing Seeds	Stream Tables
Heating and Cooling	Structures
Ice Cubes	Tangrams
Kitchen Physics	Water Flow
Mapping	Whistles and Strings
Match and Measure	

ESS materials consist of a teacher's guide and kits of materials. The kits include equipment and consumable materials. Living things such as brine shrimp eggs, frog eggs, or butterfly larvae can be ordered as needed. Some units include print materials for students such as activity cards and readers.

Major Program Goals

The ESS Reader (1970) provides the program goals of ESS:

Within the Elementary Science Study we have found basic agreement that a major aim of our project must be to encourage children to examine, analyze, and understand the world around them and to stimulate their desire to continue to do so. We view our task simply as the development of a variety of materials and techniques explicit enough to preclude the need for specialist teachers and diverse enough to awaken the curiosity and desire for understanding in children of many ages, interests, attitudes, skills and backgrounds. In approaching our task we should not attempt to make all children into scientists, but to promote their scientific literacy and general intellectual curiosity. (p. 2)

The Elementary Science Study--A History (1973) provides further clarification of the goals of ESS:

ESS was not just in the business of developing curriculum materials. Part of its preoccupation from the beginning was in working out a style of learning, a way for people to educate themselves. (p. 125)

For some of the units, introductory "Insights" pages were added at the time of commercial production to provide curriculum structure to the modules. The "Insights" pages include a list of skills and concepts that students should acquire during the unit. For example, the skills and concepts listed for the "Ice Cubes" module include:

- measure time intervals accurately
- make careful and precise observations and compare their own observations with those of others
- test a variety of materials for their insulating qualities
- verify predictions through experiments and generate simple rules to account for the behavior observed
- demonstrate an understanding of the need to keep variables constant
- determine the temperature of a number of objects by reading a thermometer
- construct tables and graphs from data obtained from their own experimentation
- determine factors which influence the melting of ice and the freezing of water
- understand that touch is not a reliable way of determining the temperature of a particular object
- establish why ice floats in some liquids and sinks in others

Research Evidence of Effectiveness

Many studies have been done on the science curricula developed in the 1960s. A quantitative synthesis procedure called "meta-analysis" that analyzes the results of this research was carried out by Shymansky, Kyle, and Alport (1983). Based on this analysis the authors conclude that there is a substantial body of literature that indicates that the science curricula of the 1960s were a successful attempt to improve science education. The following effect sizes for ESS were found:

<u>Outcome Area</u>	<u>Effect Size</u>	<u>Number of Studies</u>
Composite	0.37	N = 11
Achievement	0.09	N = 3
Perceptions	0.51	N = 1
Process Skills	0.47	N = 4

(Note: Effect size is defined as the mean difference between the treatment conditions divided by the standard deviation of the control group; a positive effect size indicates that students in the experimental curriculum performed better than the control group. Effect sizes in the range of .30 -.45 are considered modest, .45 -.60 moderate, and .60 and above high.)

Another report of their analysis of 34 studies on ESS, SAPA, and SCIS indicates the following results for students using the ESS curriculum as compared to students using a traditional curriculum (Shymansky, Kyle, and Alport, 1982):

<u>Performance Area</u>	<u>Percentile Points Gained over Traditional Curriculum</u>
Achievement	4
Attitudes	20
Process Skills	18
Creativity	26
Piagetian Tasks	2

Similar results favoring ESS were reported by Bredderman (1983) who conducted a meta-analysis on studies that compared ESS students to those using a traditional curriculum. The results are summarized below in terms of effect size.

<u>Outcome Area</u>	<u>Mean Effect Size</u>	<u>Number of Studies</u>
Science process	.19	N = 3
Science content	.07	N = 2
Affective Outcomes	.66	N = 1
All Outcomes	.26	N = 9

However, a later meta-analysis was done by Shymansky, Hedges, and Woodworth (1986) using a refined statistical procedure to study the effectiveness of the three 1960's science curricula (SAPA, ESS, and SCIS). The published results do not separate the three but generally support, although not as strongly, the cumulative data obtained in the earlier study by Shymansky, Kyle, and Alport. In addition it found that student performance was significantly enhanced by teacher inservice programs. Shymansky (1989) also reports the following significant findings:

- students in the experimental curricula (SAPA, ESS, and SCIS) outscored students in traditional curricula on a composite performance measure by 9 percentile points.
- students' perceptions of the new science programs exceeded those of traditional students' by 17 percentile points.
- process skills of students in the new curricula were 19 percentile points higher than those in traditional programs.
- ESS showed significant gains in achievement, process skills, perceptions, and analytic skills.

- performance was significantly better in the three new programs than for traditional programs for both urban and rural classrooms that were balanced by gender and reflected medium and high SES.

ANALYSIS

General Curricular Features

Curriculum design.

The ESS project brought together curriculum developers with diverse backgrounds and talents. University scientists who were specialists in their fields joined elementary teachers and science supervisors in problem solving groups for developing materials and writing units. The groups formed according to individual interests with some people working in several groups. In addition, the developers themselves did extensive field testing and rewriting with early units influencing the development of later units. Thus, the ESS units vary widely in content, style, and curriculum design (The Elementary Science Study--A History, 1973).

ESS is not a sequential curriculum; it is a series of modules that cover many areas of the life and physical sciences, mathematics, spatial reasoning, and logic. The modules span several grade levels and offer flexible use and scheduling. Some modules require daily sessions for a short period of time, others require weekly sessions of several months. Other modules provide opportunities for independent student investigation or work at learning centers. For instance, "Eggs and Tadpoles" is a life science unit for kindergarten through grade six that can be adapted for three weeks or six months. "Pattern Blocks" builds mathematical skills and can be used independently by students from kindergarten through grade six throughout the school year. "Balloons and Gases," a physical science module is appropriate for grades five through eight and requires 10-22 class sessions. One of the earth science units for grades four through nine, "Stream Tables," requires three to seven weeks.

Classroom implementation.

ESS provides open-ended opportunities for student exploration and supports them with scientific equipment, materials, activities, and philosophy. The developers actively resisted such implementation features as behavioral objectives, leading questions, and evaluation instruments. Rather, they sought to provide an environment that stimulated the student's interaction with materials and self questioning. Therefore, ESS is an unstructured program that depends on the teacher's involvement and active investigation along with students to achieve discovery and learning in the classroom.

The teachers' guides vary widely in style and in implementation features. For example, the teacher's guide for "Pattern Blocks" recommends that children be given freedom to explore and become familiar with the underlying mathematical concepts in an intuitive way rather than through direct teaching. The manual then offers photographs and activities from trial classrooms, a summary of "mathematical concepts that can be illustrated in play with the Pattern Blocks," and a bibliography. "The Behavior of Mealworms," an example of a more detailed teacher's guide, provides introductory "Insights" pages with a list of skills and concepts; ideas for planning ahead and getting started; holding class discussions; encouraging

students to record observations; integrating the curriculum; and ideas for helping students design and construct their own experimental equipment. The body of the manual then offers photographs and diagrams of mealworms, detailed descriptions of investigations, anecdotal accounts of work in classrooms during field testing trials, additional suggestions for discussions with examples of specific questions, and ideas for evaluation. In addition, the guide includes an appendix that provides extensive information on mealworms and a discussion of the complexities of experimenting with animals.

The developers of ESS encourage evaluation of student progress that considers the students' ability to complete the suggested independent projects, their overall approach to learning and habits of mind, and the level of excitement in the classroom (ESS Reader, 1970). It is left up to the teacher to develop specific measures of assessment.

Hawkins (1970) offers a sense of the character of the curriculum with his description of the three phases of science teaching. One phase leads to the other and there is no rigid sequential order. There is a free, exploratory, unguided, "Messing About" stage. Another stage he calls "Multiply Programmed" which contains rich and varied written and pictorial guidance designed to stimulate inquiry and to accommodate the diversity of student ability, interest, and style found in classrooms. A third phase which he calls, "Colloquium," includes formal and informal lectures, fully engaged discussion, and argument between teacher and student. ESS provides the materials and opportunities for these three phases to happen in classrooms. Inherent in the philosophy of ESS, however, is the essential ingredient of a teacher who is engaged in learning and capable of coaching students in independent inquiry.

Technology.

ESS modules depend on equipment such as microscopes, balances, and fulcrums, but technology such as computers is not a component of the program.

Exemplary Science Features

Science content.

From a science point of view, ESS is still exemplary, even after all these years. It was not designed to deliver a large chunk of scientific information; rather, it poses interesting problems in important scientific content areas and allows students to experimentally explore and develop their own understanding of the content area. Scientific content and process are inextricably intertwined in the ESS units. As a result, ESS does not appear dated at all: the areas that the students explore are still fundamental and interesting, and the deliberately low-tech approaches to the content area are still appropriate. The science that is presented is both accurate and understandable; the approaches suggested in the Teacher's Guides are workable and sensible.

Science process.

The ESS emphasis on the scientific process, on building and testing hypotheses, and on student directed hands-on exploration of a single area in depth is very current. However, there is less concern for imparting the big ideas and concepts of science than in developing a feel for the scientific process and an enjoyment of scientific work. The experimental work done in the

classroom is made more relevant to the students by examples of real-world situations in which the same sorts of problems come up. For example, in the "Structures," module both teacher and students are encouraged to bring in pictures of interesting real-world structures, to visit construction sites, and to model these real-world structures in a meaningful way in the classroom. Ancillary information imbedded within the teacher's manuals such as the "On Experimenting with Animals" article in the Behavior of Mealworms teacher's guide both extend the understanding of the general problem area (in this case, animal behavior) and provide information written by a scientist in the field about his research problem and how he goes about designing experiments to address fundamental questions in his subject area; there is a fair amount of career education available here, as well as content and process information. Books suggested in the reading list also tend to stress scientific process and the nature of being a scientist as well as scientific content: To Know a Fly and the Konrad Lorenz books, suggested in the "Behavior of Mealworms" module, are cases in point.

Tailoring for Special Populations

Differentiation for high ability learners.

ESS provides for differentiation for high ability learners in several ways. First, it allows high ability learners open-ended opportunities to use materials in ways that match their cognitive abilities and learning styles. The materials invite unique responses and extended, in-depth study. For instance, the "Eggs and Tadpoles" module recommends that students work with frog eggs through two life cycles--the first time to observe and raise questions; the second time to observe and research in an attempt to find some answers to those questions.

Provision for independent work is another feature of ESS that makes it particularly appropriate for high ability learners in heterogeneous classes. Modules such as "Pattern Blocks," "Attribute Games and Problems," "Geo Blocks," and "Mirror Cards" can be organized with ease into center work. Other modules such as "Behavior of Mealworms" and "Eggs and Tadpoles," and "Structures" can be made available for students to continue independent work or extended small group work after the large group experiences have been completed.

Both the modular format and the range of activities within each module facilitate adapting the materials for high ability learners. All of the modules are designed to span at least two grade levels, and the majority of them span at least four grade levels. This design feature provides appropriate challenge for students working above grade level and accommodates acceleration.

Other special populations.

ESS does not explicitly address the learning needs of special populations such as girls, minority students, and disabled students. However, certain features of the ESS program make the program useful with girls and minority students in particular. For instance, the program centers on active involvement that encourages discussion and cooperative learning. The strong philosophical base of this program that enables students to explore materials from their own perspective and with their own questions makes Elementary Science Study an accessible science curriculum for all students.

CONCLUSION

ESS is an exemplary science curriculum that engages learners in the scientific process without providing detailed instructional procedures. The student is placed in the role of investigator and is required to think critically rather than merely read or memorize facts. In addition, students learn to become self-directed learners by observing, forming their own hypothesis, testing it, and living with the hypothesis until they discover contradictory evidence.

The program is appropriate for high ability and gifted learners in that it provides for open-ended exploration, self-directed learning, extension opportunities, acceleration, and flexible pacing. ESS materials should find broad use for enhancing text-based programs for all students and for meeting the special learning needs of high ability students.

REFERENCES

- Bredderman, T. (1983). Effects of activity-based elementary science on student outcomes: A quantitative synthesis. Review of Educational Research, 53(4), 499-518.
- The Elementary Science Study--A History (1973). Newton, MA: Education Development Center.
- The ESS Reader (1970). Newton, MA: Education Development Center.
- Hawkins, D. (1970). Messing about in science. In The ESS Reader (pp. 37-44). Newton, MA: Education Development Center.
- Shymansky, J. A. (1989). What research says about ESS, SCIS, and SAPA. Science and Children, pp. 33-35.
- Shymansky, J. A., Hedges, L. V., & Woodward, G. (1990). A reassessment of the effects of inquiry-based science curricula of the 60's on student performance. Journal of Research in Science Teaching, 27, 127-144.
- Shymansky, J. A., Kyle, W. C., & Alport, J. M. (1982). How effective were the hands-on science programs of yesterday? Science and Children, 14-15.
- Shymansky, J. A., Kyle, W. C., & Alport, J. M. (1983). The effects of new science curricula on student performance. Journal of Research in Science Teaching, 20, 387-404.

Curriculum Evaluation Form

Elementary Science Study (ESS)

Phase I Review

Curriculum Design

3	2	1
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Average Rating

Reviewer #1

3.00

2.85

Reviewer #2

2.69

(Scale 1-3)

Classroom Design

3	2	1
---	---	---

Average Rating

Reviewer #1

2.34

2.49

Reviewer #2

2.64

(Scale 1-3)

Technology

3	2	1
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Average Rating

Reviewer #1

NA

NA

Reviewer #2

NA

Phase II Review

Science Content

5	4	3	2	1
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Average Rating

Reviewer #1

3.80

3.82

Reviewer #2

3.83

(Scale 1-5)

Science Process

5	4	3	2	1
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Average Rating

Reviewer #1

3.57

3.97

Reviewer #2

4.36

(Scale 1-5)

Phase III Review

High Ability Learners

5	4	3	2	1
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Average Rating

Reviewer #1

3.73

3.96

Reviewer #3

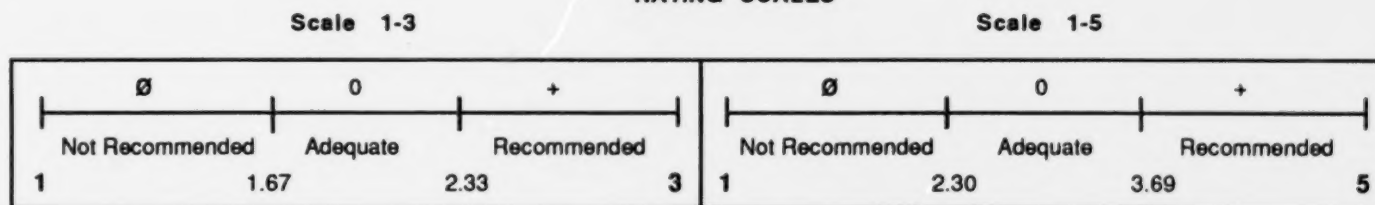
4.18

(Scale 1-5)

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Elementary Science Study	2.85 +	2.49 +	NA	3.82 +	3.97 +	3.96 +	A, B

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Full Option Science System (FOSS)**Grades 3-6**

Developed by Lawrence Hall of Science

Distributed by Encyclopedia Britannica Educational Corporation

310 S. Michigan Avenue--6th Floor

Chicago, IL 60604

1990 to date

OVERVIEW**Description**

FOSS is a hands-on science program for grades three to six organized under four topic strands: (1) scientific reasoning and technology, (2) physical science, (3) earth science, and (4) life science. When the project is complete, there will be eight modules (two in each strand) for grades three-four and eight modules (two in each strand) for grades five-six. The modules can be used to form a complete science program, or they can stand alone to supplement a program. The modules for grades three-four include measurement; ideas and inventions; physics of sound; magnetism and electricity; earth materials; water; structures of life; and human body. For grades five-six the modules include variables; models and designs; levers and pulleys; mixtures and solutions; landforms; solar energy; environments; and food and nutrition.

Each FOSS module is packaged as a classroom laboratory kit which is accompanied by a teacher's guide. The teachers' guides include lesson plans, background information, suggestions for classroom management, questioning strategies, interdisciplinary activities, suggestions for students with disabilities, and bibliographies of related resources. In addition, each module includes blackline masters for student data collection and record keeping. The teachers' guides are designed to be kept in three-ring binders. For this review, only the printed materials were considered; not the materials kits.

Major Program Goals

Although overall program goals are not specifically stated, the rationale of the FOSS science program is found in two monographs, The Biological Basis of Thinking and Learning (Lowery, 1989) and The Scientific Thinking Processes (Lowery, 1990). The FOSS program is guided by Lowery's findings that children progress through seven stages of cognitive or pattern seeking capabilities and that the stages are linked to biological development. In the FOSS program, those stages of development are coupled with the view that science is an active pattern seeking enterprise using the processes of observing, communicating, comparing, organizing, relating, inferring, and applying.

Each module begins with an overview and a statement of purpose as to what students will accomplish in that module. However, the most succinct goal statement for the module is found in the assessment materials. For instance, the purpose of the "Physics of Sound" module as stated in the module overview says: In the "Physics of Sound Module," FOSS expects students to:

- Observe and compare sounds to develop discrimination ability.
- Communicate with others using a "drop code."
- Learn that sound originates from a source that is vibrating and is detected at a receiver such as the human ear.

- Observe and compare how sound travels through solids, liquids, and air.
- Understand the relationship between the pitch of a sound and the physical properties of the sound source (i.e. length of vibrating object, frequency of the vibrations, or tension of vibrating string).
- Compare methods to amplify sound at the source and at the receiver.
- Use their knowledge of the physics of sound to solve simple sound challenges.
- Acquire the vocabulary associated with the physics of sound.
- Exercise language and math skills in the context of the physics of sound.
- Develop and refine the manipulative skills required for investigating sound.
- Collaborate in working on mini-activities.

The assessment materials include the following statement: The goals for the "Physics of Sound Module" are to develop the understanding and effective use of sound in terms of:

1. its source (vibrations)
2. its properties (pitch, volume)
3. how it travels (through solids, liquids, and gases)

Research Evidence of Effectiveness

L. F. Lowery (personal communication, November 29, 1991) cites ongoing formative assessment and research assessment as a major component of the FOSS program. The formative assessment includes a conceptualization stage where a collaborative team of scientists, cognitive scientists, science educators, science teachers, and non-science teachers conceptualize each topic. Then ideas and activities are taught in classrooms by FOSS staff while another staff member observes and takes extensive notes. Ideas and activities are reworked and tried again until a six-week module is developed. The module is finally written into a teacher guide format and accompanied by a kit of materials that emerged and was tested along with the activities. Local and national classroom trials follow the conceptualization of each module. During the local trials, the developers and other observers visit the classrooms, take notes, and interview teachers and students. In addition, classroom teachers are brought together for several hours to discuss each module with the developers. After the data is synthesized, new guides are written and new materials are developed and sent to national trial centers which include approximately 200 teachers. FOSS coordinators gather data through teacher feedback forms, classroom observations, and teacher meetings. Improvements and adjustments are made again before the modules are commercially distributed.

The research assessment used in the FOSS program examines:

1. The student's knowledge of science before and after the FOSS experience.
2. The student's attitude toward learning science--before and after experiencing the FOSS program.
3. The teacher's knowledge about science before and after the FOSS experience.
4. The teacher's attitude toward teaching science before and after teaching the FOSS program.

Information for the research assessment is derived from "FOSS Thematic Apperception Tasks" (FOSSTATs) and "FOSS Science Assessments." The FOSSTATs include a picture task and a sentence completion task. Currently, FOSSTATs have been administered to 140 FOSS local trial

students in grades 3-4 on a pre-post basis and to 112 non-FOSS local students in grades 3-4 (control classes). Similar information is being gathered for grades 5-6. Lowery reports that preliminary results have been reported to the National Science Foundation but are not ready for publication at this time.

The "FOSS Science Assessments" began as a research tool for the project but proved so successful they were revised to make available an assessment tool for classroom teachers and other researchers. Three types of assessment devices are included for each module: hands-on, pictorial, and reflective. Lowery reports that information gathered from the science assessments has been used to refine the modules and to refine the tasks. Although FOSS did not intend to publish research results, the high degree of interest in the devices has lead them to enlarge their sample size so they can report on the assessment devices themselves and make the devices available to other researchers.

To date, three masters studies and one doctoral study have been completed that look at the thinking and learning of students related to particular content within the FOSS modules.

ANALYSIS

General Curricular Features

Curriculum design.

The FOSS program is based on careful consideration of the developmental needs of children as well scientific process skills. The concepts are significant, and in-depth exploration of concepts is a hallmark of the program. Rather than cover numerous topics, FOSS presents four topics each year to allow for in-depth exploration of important scientific concepts and to provide opportunities to engage in the scientific thinking processes. In addition, FOSS considers the needs of teachers with clearly presented, elegantly designed materials.

The teacher's materials are written with a personal feel that invites participation and inspires confidence. An overview of each module provides teachers with background information, suggestions for classroom management, and the essentials of successful activity planning. The overview also contains a chart that lists activities, science concepts, science process skills, interdisciplinary activities, tool use, and extensions and projects. The detailed activity guides then provide step-by-step lesson plans.

Classroom implementation.

The FOSS activities, or lesson plans, are presented as eight-page booklets. Each activity booklet begins with an overview, background information, and a listing of student objectives. Variety and attention to the development of skills and understandings characterize the activities. For instance, in the initial activity for the "Mixtures and Solutions" module, students observe solid materials, then make mixtures with water and gravel, water and powder, and water and salt. After observing the mixtures, they use tools to separate the mixtures into their component parts. The students discover that water and salt make a solution which cannot be separated with a filter. Finally, students use evaporation to separate the salt from the water and observe the resulting salt crystals. In the other activities that comprise the module, students build on their

experiences with mixtures to explore saturated solutions, concentrations, and chemical reactions. The initial activity of the "Landforms" module requires students to create a model of their school site using earth materials and plastic cubes. Students then go through several steps to transfer the symbols of their site model to a map grid in order to learn to record and interpret data on topographic maps and aerial photographs.

Collaboration, an important element in scientific research, is a basic tenet of the FOSS program. Although the program sometimes suggests that students work in pairs or individually, FOSS activities frequently recommend groups of four with each child taking a specific role. The teacher's guides provide clear directions for the collaborative groups.

The FOSS materials are unusual in their attention to discussion as part of science learning. Each module includes a discussion of the importance of reflection time and a model for developing discussion questions. Each activity then includes a "Reflecting On the Activity" section that contains specific questions built on the model. In addition, The Scientific Thinking Processes monograph by Lowery (1990) lists provocative statements and question starters to encourage teachers to probe students' understanding of each scientific process. Thus, teachers have a model for questioning with specific examples in each activity as well as a detailed set of question stems to use for eliciting higher order thinking.

The FOSS program includes an assessment package for each module that includes a teacher guide to FOSS assessment, a record-keeping system, and three different assessment instruments with student response sheets. First, a hands-on assessment with science materials determines how well students can perform a scientific skill or process. A pictorial assessment then determines how well students can transfer concepts learned in the activities to new situations. Finally, a reflective assessment probes students' ability to use vocabulary as well as students' ability to apply the module ideas in novel ways. In addition to offering authentic assessment, the package offers students a variety of ways to demonstrate their skills and understanding.

Technology.

FOSS modules do not utilize scientific technology within the hands-on activities. However, the "Foss Activity Correlation Tables" in each module list technology resources as well as student reading materials. The technology resources include: interactive video and laser discs, films and video tapes, instructional television, and computer software.

Exemplary Science Features

Science content.

The content topics in FOSS are uniformly scientifically important. There is no trivia in the curriculum. Although the FOSS modules are organized by content subjects, conceptual themes such as systems and interaction, patterns of change, evolution, and models are woven into the activities. In the "Landforms" module for grades five-six, change is a fundamental concept of the unit. Students learn that all things change over time and change takes place when things interact. Students then create models as a technique for studying landforms.

All FOSS units use the metric system based on the developers belief that it is through constant use rather than translation that people become able to think in a system. The first FOSS module,

"Measurement," not only introduces the metric system, but it is designed to be used over an extended time and throughout subject areas outside of science. The FOSS laboratory kits for all of the remaining modules contain only metric measures.

Science process.

In order to develop the scientific thinking processes of observing, communicating, comparing, organizing, relating, inferring, and applying that FOSS addresses, students in the program investigate fewer topics in greater detail than in standard curricula. The "Ideas and Inventions" module for grades three-four demonstrates this principle. Using the theme of making things that are hard to see more visible, the module introduces rubbings, carbon printing, and chromatography. Within the rubbing and carbon printing activities, children discover, identify, and classify typical leaf venation patterns and fingerprint patterns. During the chromatography activity, they are introduced to a technique for separating and revealing pigments in water-soluble inks. After working with the processes in several contexts, children then have the skills and understanding to develop new applications of the processes and to invent something new. In contrast, many curricula ask children to "invent" without providing the necessary experiences.

Tailoring for Special Populations

Differentiation for high ability learners.

The FOSS curriculum was developed to match the cognitive developmental and learning characteristics of typical students as outlined in Lowery's The Biological Basis of Thinking and Learning (1989). Because of the developmental basis of the program, the developers generally recommend that the program be used only at the level for which it is intended. However, they acknowledge that is possible for a skilled, experienced teacher to adapt and modify curriculum materials for use at a higher or lower level. Handled with care, the curriculum therefore offers several possibilities for gifted learners.

First, the modular aspect of the program accommodates compression and acceleration. It is possible that gifted learners could accomplish all of the materials designated for a two year span within one year. Secondly, the in-depth exploration of a topic provides a starting point for extended study that can be developed by the teacher and students. Finally, the "Extensions and Applications" suggested with each activity can be used as independent activities or center work for gifted learners.

Other special populations.

The FOSS program consciously avoids bias and stereotypes by depicting minority students and girls doing the activities and by using gender-free or feminine language. In addition, the collaborative nature of the activities allows for a variety of learning styles and active involvement of all students.

The program is particularly responsive to the needs of disabled students. Each activity includes suggestions for involving students with visual impairments, physical disabilities, or learning disabilities. If a particular activity is inappropriate for some students such as those who are visually impaired, it is stated in the teacher's materials.

CONCLUSION

FOSS is an exciting hands-on science curriculum that is based on the developmental abilities of students and the demands of scientific thinking. The teachers' materials are written with grace and clarity that makes them both inviting and stimulating. The attention the developers devote to teaching strategies and curriculum design supports both the instructional requirements of teachers and the learning needs of students.

The program actively accommodates disabled students, and it reflects the presence of girls and minority students in science. Although not specifically designed for high ability learners, it can be modified to meet their needs. FOSS is a flexible, substantive science curriculum that accommodates a wide range of student diversity and ability.

REFERENCES

- Lowery, L. F. (1989). The Biological Basis of Thinking and Learning. Berkeley: University of California, Lawrence Hall of Science, Full Option Science System.
- Lowery, L. F. (1990). The Scientific Thinking Processes. Berkeley: University of California, Lawrence Hall of Science, Full Option Science System.

Curriculum Evaluation FormFOSSPhase I ReviewCurriculum Design

3 2 1

Average Rating

Reviewer #1

2.80

2.80
(Scale 1-3)Classroom Design

3 2 1

Average Rating

Reviewer #1

2.90

2.90
(Scale 1-3)Technology

3 2 1

Average Rating

Reviewer #1

NA

NA

Phase II ReviewScience Content

5 4 3 2 1

Average Rating

Reviewer #1

3.83

4.42

Reviewer #2

5.00

(Scale 1-5)

Science Process

5 4 3 2 1

Average Rating

Reviewer #1

4.64

4.37

Reviewer #2

4.10

(Scale 1-5)

Phase III ReviewHigh Ability Learners

5 4 3 2 1

Average Rating

Reviewer #1

3.81

4.16

Reviewer #3

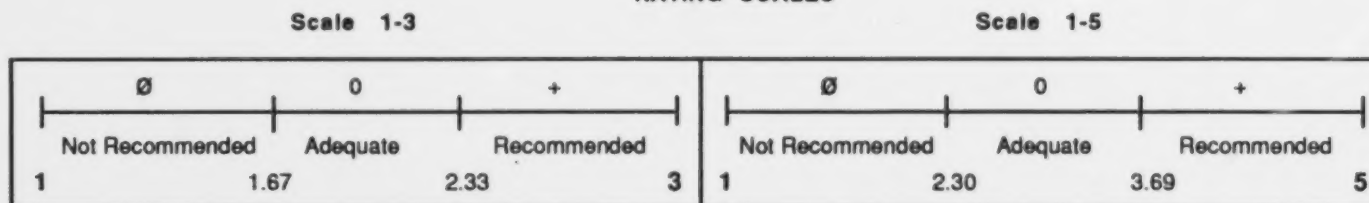
4.50

(Scale 1-5)

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Full Option Science System (FOSS)	2.80	2.90	NA	4.42	4.37	4.16	A, B, C, E
	0	+		+	+	+	

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Great Explorations in Math and Science (GEMS)
Lawrence Hall of Science
University of California
Berkeley, CA 94720

Grades K-10

OVERVIEW

Description

GEMS is a program of guided discovery that enables instruction of both science content and process skills through hands-on activities. There are currently more than 30 units in the GEMS program, each focused on a single topic and described in its own teacher's guide. A teacher's handbook gives an overview of all the GEMS materials and makes recommendations for using the units, either as supplements to existing curriculum or as a stand-alone curriculum organized by suggested themes. Several of the units, such as Quadice and Height-O-Meters, focus on math concepts. The rest are science units with a strong mathematical component. The only materials provided for students are data sheets (masters are included in teacher's guides). There are no textbooks. Each guide presents a comprehensive set of directions for hands-on activities with supplemental background information and suggestions for extensions. The activities require readily available, inexpensive materials. No special training in math or science is required for teachers although training sessions are available if desired. Each guide indicates a range of recommended grade levels. Time frames are flexible, ranging from 2 to 15 class sessions per unit.

GEMS is a dynamic set of materials. Its modular design facilitates the addition of new units. One of two new units due to be published in Spring of 1992 is called "The Bubble Festival." Designed for grades K-6 this unit is structured around the use of a learning station. An extension handbook for literature is to be published in Fall of 1991. Teachers are encouraged to send anecdotes and ideas for later revision of existing units. Lawrence Hall of Science (LHS) publishes a newsletter called "GEMS Network News" that includes letters from users of the materials, responses to those letters, and ideas from LHS.

Major Program Goals

The major objectives of the GEMS program are:

- To create independent learners and critical thinkers.
- To increase students' understanding of pivotal science and mathematics concepts.
- To promote mastery of key science and mathematics skills.
- To build positive attitudes towards science and mathematics.

Research Evidence of Effectiveness

An intense formative evaluation procedure is followed in the development of all GEMS units. Potential activities are tested in classrooms and either modified or eliminated as feedback indicates. Eight to ten local classroom teachers (urban and rural, experienced and novice, young and old) field test the guides. The teachers fill out detailed evaluation forms and each session is observed by a GEMS team member. This data is used to revise the guides, which are then sent to 100 teachers at five national trial sites. More evaluation forms are collected and

revisions are made again. A limited number of units are printed, used, and polished before nationwide distribution of the final product.

Additional research has been conducted on three of the units.

- "Children's Cosmographies: Understanding the Earth's Shape and Gravity" (Eratuuli, 1990) describes the seminal research that laid the foundations for the Earth, Moon, and Stars guide. The study found that children's notions about the earth's shape and gravity are often incorrect, result from observed phenomena and cultural transmission of information, and are affected by verbal and spatial abilities. Results also indicate that mature concepts are acquired gradually, usually culminating by the seventh or eighth grade. The findings imply the need for effective education in these concepts.
- "The Experiences of Visitors in a Physics Discovery Room" (Sneider, Kurlich, and Friedman, 1984) evaluates the effectiveness of the exhibits described in The Wizard's Lab. The authors conclude that visitors in a science discovery lab do engage in the kind of learning activities that lead to both enjoyment and understanding. However, the study was not designed to determine whether there is an increase in understanding.
- "Learning to Control Variables With Model Rockets" (Sneider and Pulos, 1983) tested the educational effects of Experimenting With Rockets. Results indicate that 9-15 year-olds who were exposed to the rocketry program significantly improved their ability to control variables.

ANALYSIS

General Curricular Features

Curriculum design.

The GEMS approach to teaching science is "doing before explaining." The units are intended to illustrate essential scientific concepts and methods while engaging the student in critical thinking and hands-on activities. Activities within each unit build on one another so that they are not simply a collection of experiments on a single topic. A supplemental publication, "To Build a House," outlines ten major themes that run throughout GEMS materials. These themes are: systems and interactions, stability, diversity and unity, models and simulations, matter, patterns of change, energy, evolution, structure, and scale. A chart is provided to help teachers identify the units where each theme is featured. Themes can be highlighted for an individual unit or an entire curriculum can be organized around selected themes. A second chart lists the nine categories that illustrate the nature of science and also the units which feature each category. These categories are: scientific community, science and technology, changing nature of facts and theories, creativity and constraints, theory-based and testable, cooperative efforts, objectivity and ethics, real-life applications, and interdisciplinary. Sample year-long science programs for grades 3, 6, and 8 are included.

Classroom implementation.

The primary roles of the teacher in the GEMS program are a facilitator of science activities and

a discussion leader. The teacher sets up materials for the planned activities. Data sheet masters are provided in the teacher's guide but very little other material is provided for the students. The data sheets are not step-by-step activity sheets that lead students through every aspect of the lesson in "spoon feeding" fashion but provide a convenient format for recording data. Directions are usually read to students. Often students are instructed to design or re-design an experiment. For example, in Hot Water and Warm Homes From Sunlight, the students are asked to design a controlled experiment to determine whether a covered pan or an uncovered pan produces warmer water when placed in sunlight.

Ample opportunities are provided for problem finding and solving. Teachers are encouraged to create questions in the open-ended style of the examples given in the unit guides. Students usually work in small teams. The teacher handbook emphasizes experimenting and drawing conclusions as opposed to getting the "right answers."

GEMS units can be implemented as whole class activities with students working in small groups. Materials and directions could also be set up at a learning station in the classroom for use as enrichment or extension for an individual or small group, provided the students are able to function without constant guidance from the teacher.

GEMS does not provide specific pre- and post-assessment procedures for most units. Earth, Moon, and Stars has a questionnaire that could be used for both purposes. Teachers are given suggestions for alternative assessment procedures such as collecting observational data on student behaviors, having students write what they know before and after each activity, posing a new problem where the students are expected to apply what they have learned, and doing a demonstration where errors are made and students make suggestions for improvement.

The teacher's guide is very easy to follow. Summary outlines are included at the end of each guide and can be used as checklists during class. A section in each guide, called "Behind the Scenes," provides background information for teachers. Some units have a "Resources" section that is mainly for teacher use but could be a source of extension material for a highly able learner. Each unit contains a section called "Going Further" that is rich in open-ended extension ideas for whole class activities or individual projects. Some examples are:

- In Bubbleology students are asked to develop their own ideal bubble solution.
- Also in Bubbleology students are instructed to determine the volume of their lungs by blowing bubble domes.
- In Acid Rain students plan and carry out their own investigation of the effects of acid on various materials such as brick, nylon, styrofoam, concrete, marble, wood, etc.

Technology.

The use of technology is not featured in this program.

Exemplary Science Features

Science content

The material presented in the GEMS units displays many characteristics of exemplary science. The concepts are significant and are covered in sufficient depth to do them justice. The information is accurate and presented well with a nice balance of theory and practical applications. Mathematics is effectively integrated into the science activities. Many other interdisciplinary connections are also provided. Reading about the discovery of vitamin C and mixing paint colors are examples of connections to history and art. Some teachers have students keep a laboratory journal. Assessments can be done as writing exercises or as authentic science activities.

Many environmental issues are presented in the GEMS units. They include acid rain, global warming, toxic waste, and energy conservation. These can be used as the basis for discussion of ethical aspects of our treatment of the planet and its inhabitants.

Science process

Scientific process skills are skillfully demonstrated in the GEMS units. The activities avoid verification exercises or demonstrations by the teacher. Excellent opportunities are included for hands-on scientific investigation. Students work together in lab work where they are expected to form and test hypotheses. The emphasis is on critical thinking rather than merely generating "right answers." This is reflected in the questioning style that is modeled in the guides. There is room for things to go wrong and for diversity of opinions. The discussion sessions after experiments are valuable opportunities for students to learn how to deal with conflicting results. The scientific convention in Oobleck: What Do Scientists Do? provides a marvelous view of the kind of discussion and analysis of scientific findings that is actually found in the scientific community. It is also an exercise in communication skills for students. The GEMS program communicates a realistic sense of what scientists do--questioning, investigating, and making sense of the world in a cooperative way.

Links to real scientists, mentors, and community resources are not featured in this program. However, the teacher or a community person could act as a mentor for students who might pursue extension activities as individual projects. Career awareness is not stressed, but the Oobleck unit does a good job in demonstrating how scientists function and concludes with specifics about scientists working in space exploration.

Tailoring for Special Populations

Differentiation for high ability learners

GEMS contains many key components of a good science program for high ability learners. Among them are:

- 1) Inquiry-based activities that include true experimental work.
- 2) Independent lab work.
- 3) Scientific reporting.
- 4) Problem finding, solving, and reevaluation.

- 5) Concepts that are significant and challenging.
- 6) Higher level thinking skills that are encouraged by the structure of the activities and the style of questioning.
- 7) Opportunities to develop advanced products.
- 8) Opportunities for extension activities that can be adjusted for student ability and interest.
- 9) Identification of themes throughout the GEMS units. These can be emphasized with high ability students in a meaningful way since high ability students are readily able to handle abstract approaches of organizing concepts. The use of the booklet, "To Build a House," is strongly recommended as a teacher resource for this purpose.
- 10) Emphasis on creative thinking.

If these materials are used as a supplement to another set of curriculum materials then it is not necessary for them to include every aspect of a model curriculum for high ability students. However, as a stand-alone curriculum several areas should be supplemented for these learners. For example, there is not an obvious provision for testing out of certain portions of the curriculum. The acceleration of content needs to be managed by the teacher. If she has some method to diagnose the needs of her students, then selection of units, pacing of activities, assignment of independent work, and emphasis of themes can be done meaningfully for high ability students. Moral and ethical dilemmas associated with relevant issues should be considered and debated. Also, scientists, community resources, and mentors are not incorporated into the units, but these features can be provided through other resources.

GEMS materials could be used as enrichment supplements for high ability students in a heterogeneous classroom where the rest of the class is working from a basal text. Some of the activities could be adapted in a learning center format. In a classroom where a GEMS unit is being used by the whole class, there are a number of suggested extension activities that would serve to challenge high ability students. In a self-contained class of high ability students the early activities in each unit could be done quickly leaving time for the later experiments and more open-ended activities that would be most appropriate for these learners.

Other special populations

The GEMS materials contain no special features that are particularly responsive to female, minority, and disabled students.

CONCLUSION

GEMS is a program that would benefit all students with its emphasis on scientific process and its hands-on approach. However, it is a program that holds special promise for high ability and gifted learners because of its orientation toward higher level thinking, creative thinking, and opportunities for extended investigations.

REFERENCES

- Eratuuli, M., & Sneider, C. (1990). The experiences of visitors in a physics discovery room. Science Education, 74 (4), 481-493.
- Sneider, C., Kurlich, K., Pulos, S., & Friedman, A. (1984). Learning to control variables with model rockets: A neo-plagetian study of learning in field settings. Science Education, 69 (4), 463-484.
- Sneider, C., & Pulos, S. (1983). Childrens Cosmographies: Understanding the earth's shape and gravity. Science Education, 67 (2), 205-221.

Curriculum Evaluation FormGEMSPhase I ReviewCurriculum Design

3	2	1
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Average Rating

Reviewer #1

2.73

2.71

Reviewer #3

2.69

(Scale 1-3)

Classroom Design

3	2	1
---	---	---

Average Rating

Reviewer #1

2.63

2.68

Reviewer #3

2.72

(Scale 1-3)

Technology

3	2	1
---	---	---

Average Rating

Reviewer #1

NA

NA

Reviewer #3

NA

Phase II ReviewScience Content

5	4	3	2	1
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Average Rating

Reviewer #1

4.16

4.16

Reviewer #2

4.16

(Scale 1-5)

Science Process

5	4	3	2	1
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Average Rating

Reviewer #1

3.78

3.82

Reviewer #2

3.86

(Scale 1-5)

Phase III ReviewHigh Ability Learners

5	4	3	2	1
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Average Rating

Reviewer #1

3.75

3.79

Reviewer #3

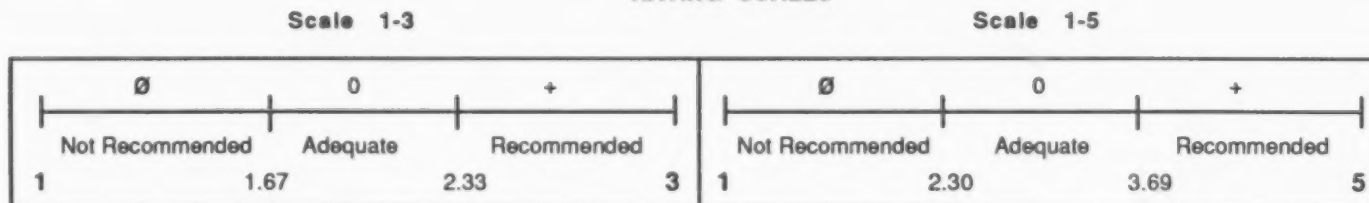
3.83

(Scale 1-5)

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Great Explorations in Math and Science (GEMS)	2.71 +	2.68 +	NA	4.16 +	3.82 +	3.79 +	A, B

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Insights Elementary Science Curriculum

Grades K-6

Developed by Education Development Center, Inc.

Distributed by Wings for Learning

P.O. Box 660002

160 Green Hills Road

Scotts Valley, CA 95067

1991 to date

OVERVIEW**Description**

The Insights Elementary Science Curriculum, a product of the Improving Urban Elementary Science Project of the Education Development Center, is an inquiry-based program consisting of thematic modules. When the project is completed, the modules will be able to be used as a complete curriculum, or as individual modules to supplement an existing curriculum. The modules that are planned for development for each grade level are listed below:

Grades K-1	Living Things, Balls and Ramps, Myself and Others, The Senses
Grades 2-3	Habitats, Liquids, Plants, Simple Machines, Sound
Grades 4-5	Bones and Skeletons, Mysterious Powders, Circuits and Pathways, Reading the Environment, Changes of State
Grade 6	Human Body Systems, Structures, There is No Away (waste generation and disposal)

"Myself and Others," "Bones and Skeletons," and "Circuits and Pathways" were examined for this review.

Each module is presented as a teacher's manual in a three-ring binder format. The manual includes all instructional and assessment materials needed by the teacher, blackline masters to reproduce for student journal keeping, and a list of supplies and equipment needed for the unit.

Major Program Goals

Insights authors state that the program is designed to:

- provide students with exciting science experiences that extend their natural fascination with the world and help them learn the science skills and concepts they will need in later schooling and in life.
- provide teachers with the guidance and background they need to teach science in the true spirit of scientific exploration and discovery

In addition to the overall program goals stated above, each module lists goals, major organizing themes, concepts, and the science thinking and process skills that are pertinent to that module. As an example, the goals of the "Circuits and Pathways" module are listed below:

- Students acquire knowledge of some of the properties of electricity in simple parallel and series circuits.
- Students acquire understanding of switches, fuses, conductors, and insulators.
- Students develop science thinking and process skills.
- Students develop cooperative group skills.
- Students apply their knowledge of simple circuits to their everyday lives.

Research Evidence of Effectiveness

Research evidence of effectiveness of the Insights program was obtained from pages 1-9 of the Improving Urban Elementary Science Project: A Collaborative Approach. Year II Report (Education Development Center, 1988). The report describes the collaboration with classroom teachers in San Francisco, Cleveland, Los Angeles, Boston, Baltimore, and Montgomery County (Maryland) during the development and field testing of the modules. The design for the evaluation of the modules includes:

- examination of the texts for congruence with the proposed objectives
- examination of the effectiveness of the modules in terms of student outcomes
- review of the implementation of the modules in the classroom, as reported by teachers in daily logs and Likert-type feedback forms.
- observations and interviews with teachers to establish use of text, classroom strategies, resources and usability of kits, instructional approaches, student interest and attitudes, and teacher attitudes
- review of the implementation of, and teacher feedback on assessments.

One commitment of the project was alternative methods of assessing student progress, and it received specific attention during the evaluation process. The evaluators found a dissynchrony between project goals for alternative methods of assessment and teachers' willingness to implement them. In particular, teachers believed they knew the capabilities of students and that performance assessment was unnecessary. Teachers also believed that traditional tests were more important than performance assessments, and they cited a lack of time for recording observations of student work.

Although little quantitative data was included in the portion of the report seen for this review, a representative module was reported as effective in terms of global student gains. For the "Circuits and Pathways" module, the report states:

When scores were converted to percentages, there was an average pre-post gain of 26% across all classes, with individual students showing gains up to 40 percentage points. In addition, teachers were enthusiastic about the level of student interest, involvement, and discovery.

The report went on to say that evaluators recommended re-examination of materials where there were significant numbers of students who showed confusion on key concepts.

ANALYSIS

General Curricular Features

Curriculum design.

The Insights modules demonstrate all the components of good curriculum design. Each module includes: an overview of goals, concepts, and skills; an introductory questionnaire that serves as a pretest; inquiry-based activities that are engaging, sequential, and significant; a variety of authentic assessment measures; extension activities that challenge various levels of student ability, and carefully selected resources for students and teachers. Major organizing themes of systems, change, structure and function, diversity, cause and effect, and energy are integrated into the modules.

The Insights modules allow an investigation of content that is appropriate to the ability of the students. First, the pretest questionnaire alerts teachers to concepts students already understand or partially understand. Secondly, the activities include challenges that add complexity for students who have mastered the basic concepts and skills. For instance, a "Circuits and Pathways" learning experience in which students construct brightness meters challenges students to invent a solution for using more than one brightness meter to measure the brightest bulbs.

Classroom implementation.

Each module in the Insights program contains approximately 15 "learning experiences." One 45-minute class period is suggested for most of the experiences, with some experiences taking two class sessions. The introductory questionnaire and the final assessments require additional time.

Each "learning experience" or lesson plan includes an overview, objectives, a materials list, directions for advance preparation by the teacher, a teaching sequence, science notebook pages for students, assessment checks, and extensions. With easy-to-follow directions and extensive support for teachers, the materials are specifically designed to be used by teachers with varying degrees of science background.

The experiences are organized around four phases: getting started, exploring and discovering, processing for meaning, and extending ideas. This organization allows students to discuss and express ideas, to question, to work with materials and make discoveries, to articulate their learning, and to relate new ideas to old ones. Generally, students work in pairs or groups of four, but the journal-keeping and notebook pages that accompany each experience provide opportunities for students to respond to the activities on an individual basis.

The assessment framework which is an integral part of each module distinguishes the Insights program from other elementary school science curricula reviewed. First, there is a pretest questionnaire that reveals students' misconceptions and enables teachers to determine which concepts students already understand. Charts and recording forms are provided for teachers' observations and anecdotal notes. One or two embedded assessments in each module allow teachers to observe student mastery of science concepts, problem solving, and group skills while the students are learning. A final assessment measures students' growth and change

during the module. The final assessment materials include both a hands-on performance task and a questionnaire that includes questions from the introductory questionnaire. With its variety and integration of assessment measures, this curriculum offers a model for evaluation of science learning.

Technology.

Insights does not utilize technology such as computers and video in its instructional program.

Exemplary Science Features

Science content.

The three Insights modules that were available for this review offer important fundamentals of science with content that is exciting and covered in significant depth. Although the themes of systems, change, structure and function, diversity, cause and effect, and energy are not explicitly developed, their inclusion offers opportunities to link the Insights topics to broad scientific concepts. The suggestions to invite people who work with science or its applications such as scientists, technicians, and custodians into the classroom extends the content to include current technology and the societal dimensions of science.

Science process.

The curriculum is based on the Insights "Science Thinking and Process Skills Framework" that infuses process skills into every learning experience. The framework is organized into the following four categories: exploring and observing, communicating, understanding, and applying. Instead of the traditional, linear "scientific process" taught in many schools, the framework allows students to experience the ways scientists work and the many skills they use. For instance, the framework category of "understanding" is subdivided into the four components of organizing, interpreting and analyzing, problem solving, and evaluating. While organizing, students collect data and classify. When interpreting and analyzing, they question, relate, compare, contrast, and measure. Their problem solving work includes recognizing patterns, predicting and forecasting, planning experiments, formulating experimental hypotheses, controlling and manipulating variables, experimenting, and validating reliability. Finally, in the evaluating component, they synthesize, build models, identify and apply value norms, draw conclusions, and make decisions. Scientists' work does not end with problem solving, they must also communicate. The communicating piece of the framework includes both the verbal and nonverbal skills of discussing, presenting, writing, explaining, drawing, graphing, modelling, and diagramming. The skills addressed in "applying" category of the framework include integrating, using knowledge to solve problems, extending knowledge to analogous situations, and inventing. Each learning experience of the Insights modules include skills from various categories of the Thinking and Process Skills framework so that the skills from one category such as communicating enhance the skills of another category such as understanding. Thus, the process skills become integrated and circular with one building upon another.

Tailoring for Special Populations

Differentiation for high ability learners.

The Insights curriculum is intended to have broad application in the nation's urban classrooms. It is not specifically designed for gifted learners. However, the careful attention the developers have given to curriculum design and to meeting the needs of a diverse population make it readily adaptable for gifted learners. Each learning experience within the modules includes significant extensions for student work. Related reports and open-ended activities allow students to work independently and in-depth. The curriculum also acknowledges various ability levels of students. For instance, an extension activity suggests grouping the students who had been successful in lighting a bulb in at least four ways to combine their materials and discover other possible configurations. The suggestion not only groups students of similar ability, it gives capable students the opportunity to continue working rather than waiting for others to catch up.

For gifted learners, the Insights curriculum can be extended by the earlier Elementary Science Study materials developed by the Educational Development Center. "Batteries and Bulbs I and II" offers additional, compatible resources which can be located through the ERIC database. "Batteries and Bulbs II" includes activities for making battery testers, electronic games, flashlights, and radios.

Other special populations.

Designed to address the needs of urban school systems that serve large numbers of low-income, minority, and special needs children, the Insights curriculum promotes diversity, acknowledges various learning styles, and utilizes the experiences of urban children. The program promotes language development and helps children to value themselves. Cooperative learning, a tenet of this program, builds communication and group skills. Each module includes explanatory letters for children to take home and activities designed to involve families in the students' science study.

The "Myself and Others" module for kindergarten and first grade specifically helps children develop an understanding of themselves and an appreciation of others. Integrating the themes of diversity and change, the module explores skin color and hair variations as well as comparing hand size and height. The instructional materials offer teachers specific suggestions to support student understanding of individual and group differences. Again, this curriculum successfully links goals and objectives with specific activities to accomplish the goals.

CONCLUSION

Insights is an innovative, exciting science curriculum. It offers teachers concrete methods for delivering and assessing important science content along with vital science process skills. Several features distinguish Insights. First, it is based on a comprehensive "Science Thinking and Process Skill Framework" that enables students to experience all aspects of "doing" science. Secondly, it is one of the few curricula available which targets the diversity of students found in urban settings. Third, it features an unusually complete, integrated assessment procedure. The three modules that are currently available, "Myself and Others," "Bones and Skeletons," and "Circuits and Pathways" provide an enticing introduction to the remainder of the curriculum which is under development.

The carefully planned Insights curriculum accommodates the needs of high ability learners. The program is open-ended, and it encourages serious investigation of science content. In addition, the teachers' guides include worthwhile extension activities as well as suggestions for pacing learning and varying the grouping of students.

REFERENCES

Education Development Center (1988). Improving Urban Elementary Science Project: A Collaborative Approach. Year II Report. January 1, 1988-December 31, 1988.
Newton, MA: Author.

Curriculum Evaluation Form**Insights****Phase I Review****Curriculum Design**

3 2 1

Average Rating

Reviewer #1

3.00

2.96

Reviewer #2

2.91

(Scale 1-3)

Classroom Design

3 2 1

Average Rating

Reviewer #1

3.00

3.00

Reviewer #2

3.00

(Scale 1-3)

Technology

3 2 1

Average Rating

Reviewer #1

NA

NA

Reviewer #2

NA

Phase II Review**Science Content**

5 4 3 2 1

Average Rating

Reviewer #1

3.50

3.85

Reviewer #2

4.20

(Scale 1-5)

Science Process

5 4 3 2 1

Average Rating

Reviewer #1

4.58

4.33

Reviewer #2

4.08

(Scale 1-5)

Phase III Review**High Ability Learners**

5 4 3 2 1

Average Rating

Reviewer #1

4.16

4.53

Reviewer #3

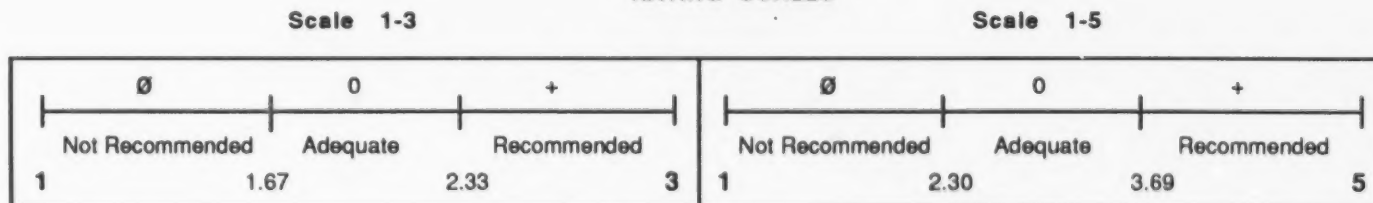
4.90

(Scale 1-5)

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Insights	2.96	3.00	NA	3.85	4.33	4.53	A, B, C, D
	+	+		+	+	+	

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

National Geographic Kids Network
 National Geographic Society
 Educational Services
 Washington, D C 20036

Grades 4-6

OVERVIEW

Description

National Geographic Kids Network offers students a new way of learning science. In the program, students collect data on an assigned topic and use telecommunications to share their data with other students across the United States and around the world. Currently, the curriculum consists of four units: "Hello!" ("Hello!" is an introductory unit that covers experimental methods and telecommunications procedures by utilizing a pet survey.) "Acid Rain," "Weather in Action," and "What's in Our Water?" A unit called, "Too Much Trash," and units on health and energy are planned for future release. Because each unit runs during a prescribed eight-week period during the school year, classes around the world study a topic simultaneously and collect correlating data that reflects their geographical area. A scientist assigned to each research team assists with analyzing the data via the telecommunications network.

The materials for each NG Kids Network unit consists of two parts. First, there is the one-time purchase of a materials kit for each unit. Secondly, there is a tuition and telecommunications fee that must be paid for each group of thirty students each time the unit is used. The materials kit includes: computer program software, a software manual, thirty copies of a student handbook, reproducible activity sheets, and a teacher's guide as well as posters, maps, or experiment test kits specific to each unit. The tuition and telecommunications fee includes: the NG Kids Network program disk, access to the telecommunications network, 120 minutes of telecommunications time, data analysis by a unit scientist, and program support.

Equipment that the site must provide include: an Apple IIGS computer with a least 512K and ROM version 01 or greater, a color monitor, a mouse, one 3 1/2" disk drive and one 5 1/4" disk drive, a printer, and a modem as well as a dedicated outside phone line.

Major Program Goals

The activities and concepts that are common to all NG Kids Network units include:

- working as research scientists, investigating scientific questions
- collaborating to solve problems
- using computers and telecommunications to exchange information
- collecting data carefully and consistently
- organizing and displaying data using graphs and maps
- finding patterns in scientific data
- learning how the environment affects our culture and how our culture affects the environment

Research Evidence of Effectiveness

Evaluation by Technical Education Research Centers (1990) of two National Geographic Kids Network units, Hello! and Acid Rain focused on assessing student gains in three general areas:

- developing science process skills, particularly those related to the collection and interpretation of data,
- developing content knowledge to which these process skills can be applied,
- developing a further understanding of the overall nature of the scientific enterprise.

The developers reported that students demonstrated significant gains in their ability to organize and represent data. They were better able to make graphs of data and to attend to different characteristics of data sets when interpreting information. Students also increased their skills in content areas such as in geographical place knowledge, ability to use latitude and longitude to identify map location, and factors contributing to acid rain. Specific measures of students' attitude toward science indicated modest changes from pre- to post-test. Students developed a more articulated view of the nature of scientific inquiry on several factors: they were able to indicate when their answers to questions about acid rain were guesses or "predictions;" they demonstrated a greater appreciation for the variety of activities that constitute the study of science; they increased their understanding of what constitutes a scientific experiment.

ANALYSIS

General Curricular Features

Curriculum design.

The integration of science and geography combined with using computers for data analysis and communication makes National Geographic Kids Network a unique and multifaceted curriculum. The program allows students to work as scientists, to experience the "aha" of interpreting authentic data, to collaborate in meaningful ways, and to link geographical and scientific questions. In order to accomplish the many aspects of the program, the scientific content and complexity of the units is limited, but the issues raised by the study are of global concern.

In the unit, "What's in Our Water?" students investigate the source of their school's tap water, observe a watershed demonstration that illustrates how substances get into water, learn about the benefits and hazards of nitrate, consider context and concentration when defining pollution, test water samples for chlorine content, and measure nitrate in their school's tap water. During the data analysis phase of the unit, students examine a case history of an area with a potential nitrate problem, look at different interpretations of data, examine data from the entire network in order to compare it with their own data, look at the international implications of water pollution problems, and develop a hypothetical water policy.

Similarly, in the "Acid Rain" unit, students learn about acids and the pH scale by measuring acidity and alkalinity using pH paper. They design rain collectors, collect rain samples, and learn how to test rain samples. The students then explore how acid rain is formed and

investigate local sources of acid-producing gases as well as how prevailing winds affect the distribution of acid rain. Additionally, the students conduct an experiment to observe and describe the effects of acid on nonliving things. In this unit, students make predictions about the acidity of rainwater in the various locales of their computer-linked research teams. Later, they examine rain data received from their distant teammates, evaluate their predictions, and search for global patterns. Finally, the students consider two positions on acid rain and vote on which position most closely resembles their own.

The "Weather in Action" unit introduces students to basic weather terminology and skills such as reading a thermometer, identifying cloud types, observing sky conditions, demonstrating the water cycle, and graphing and mapping weather data. During this unit, students survey community members about memorable weather events and about how they use weather data for their jobs. The data they exchange with their research teammates via telecommunications includes their survey results as well as daily temperature measurements and weather observations. The students then map the network temperature data and examine the surveys from their teammates.

All of the units share several common features. First, students identify the longitude and latitude, or "global address," for their own school. Then they locate the global address of their research teammates on a world map and computer maps. Early in each unit, the students send an electronic letter to their teammates and receive similar letters that reveal local, unit-related information. In the weather unit, for instance, they exchange the survey results of memorable community weather events. In each unit, students study maps, predict then compare data of teammates, and study patterns in world-wide accumulated data. In addition, students receive suggestions and probing questions from a unit scientist.

The real-life investigations and exchange of data by telecommunications has potential both for engaging students and providing a deeper understanding of content. As students conduct their own experiments and communicate with their peers as investigators, they discover how science, geography, and culture interact with one another. The effects of the subject under study--weather, acid rain, or water pollution--are seen on real people with whom the students have immediate contact.

Classroom implementation.

Because NG Kids Network is designed to be used during a prescribed eight-week period with specific data to be collected and communicated, the majority of the investigations and activities are necessarily prescribed and teacher directed. Clear, easy-to-follow directions are provided for each self-contained session. The activities are designed for simplicity and success so that diverse groups of students scattered throughout the world can exchange and compare data.

The curriculum is designed for small, collaborative group work. As one group works with the computer, another group might be using wall maps or collecting data at a site on the school playground. The teacher's manual for each unit offers extensive organizational suggestions and each unit is organized in a similar fashion. Therefore, teachers and students can progress from one unit to another with ease.

Teacher-directed discussion plays a major role in the NG Kids Network curriculum. Throughout the units, various types of questions are provided for teachers to pose for their

students. For instance, the "What's in Our Water?" unit lists questions that can be answered from the student handbook: "Why do people use nitrate fertilizer?" "How does nitrate fertilizer get into water?" "What are some sources of nitrate (other than fertilizer)? Other questions require students to analyze and evaluate why they placed certain limits on soil in water in the different contexts of swimming, watering, washing, and drinking. Examples of these questions include: "How did the students decide on the limits they established? (What criteria did they use?)" "How did the context of the water affect the limits they set? (Which criteria were most important in each context?)" "Would students consider soil a 'pollutant'? Why or why not?" Reflecting the preset character of the units, no questioning heuristic is provided for teachers to develop their own questions, rather questions are explicitly stated.

In order to evaluate student growth during the units, teachers must develop their own assessment measures. Observation and using activity sheets to assess performance are the only methods which are suggested in the resource materials.

The resource materials for each unit consist of appealing, easy-to-use manuals. The teacher's manuals which average 57 pages are organized by lesson plans that list objectives, preparation and materials, activities, teaching tips and background, and extension activities. A software manual provides clear instructions for setting up the computer and using the necessary software. The fifteen-page "Kids Handbook," features the beautiful and expected National Geographic photographs and is reminiscent of the children's magazine National Geographic World. Each unit includes approximately fifteen reproducible activity sheets as well as wall maps and/or test kits. Telecommunications from the scientist assigned to each unit complete the resources.

Each unit contains worthy extension activities that can be pursued by individual students or small groups of students. Examples of extension activities from the unit "What's In Our Water?" include: conducting a more extensive study of the local water supply system, following the news for information about local, national, and international water pollution problems, using topographic maps of the local area to identify water supply and use, visiting a water treatment plant, and conducting a more extensive study of chlorine in drinking water.

Technology.

NG Kids Network offers students and teachers the opportunity to use the computer in functional, important ways. Within the units students use the computer to record, graph, and analyze data from their experiments. Also, they use it as a word processor to write letters and reports. Finally, they use it for telecommunications to exchange data from across the United States and around the world. In this curriculum, the computer enables students to study science in ways that mimic the explorations and research of working scientists.

The NG Kids Network materials are written in a lucid style that invites confidence and participation. However, the curriculum makes multiple uses of computer technology which may require extra support or training for teachers in the initial stages of implementation.

Exemplary Science Features

Science content.

Keeping the caveat in mind that NG Kids Network is a set of limited, modular units, and not a full curriculum, the program exhibits various elements of exemplary science. The topics which are timely and important link broad scientific concepts such as chemical systems, ecosystems, and change. In addition, the study is interdisciplinary overlaying science with geographical and cultural considerations.

Science process.

The units integrate scientific process with content by investigating real problems. Students have the opportunity to set up experiments, collect data, analyze, and then compare their data with that of students in distant places. Occasionally, students may experience the uncertainty and frustration of ambiguous results or a contaminated experiment. Although the communication with the working scientist is limited, students have access to an "expert" in the field, an unusual feature in science programs. NG Kids Network is an imaginative program that offers an introduction to the essentials of science process and a glimpse of its content.

Tailoring for Special Populations

Differentiation for high ability learners

NG Kids Network is an open-ended, flexible program designed for broad use. Although it is not targeted specifically to gifted learners, it can be adapted for their needs in several ways. First, the program is accessible to high ability fourth graders who would find the experiments challenging; whereas the content would not be challenging to high ability sixth-grade students. The prescribed nature of the program dictates that it must be matched with the ability level of the students rather than compressed or changed substantially.

The units can be expanded for gifted students by including additional resources and by elaborating on the extension activities. Independent study projects in which the students design more complex experiments would add depth to the content and process.

Although each unit concludes with a suggestion for a presentation or a report, sufficient time is not allowed for a high-quality product. Gifted students should be required to develop a product for each unit that is worthy of their talents.

Other special populations.

With National Geographic Kids Network, students encounter other students with similar concerns but with diverse traditions and backgrounds. The multicultural curriculum not only avoids gender and ethnic stereotyping, it promotes understanding and reflects positive pluralistic images. Thus, the curriculum addresses some of the needs of girls and minority students.

CONCLUSION

National Geographic Kids Network is an innovative program that can be used to supplement any science curriculum. It offers students a unique opportunity to experience science as it is practiced and to gain a global perspective through telecommunications. Although the units are short and limited in scope, they contain elements of exemplary science content and process. Experienced teachers will find the materials offer built-in springboards for adapting the curriculum for gifted learners.

REFERENCES

Technical Education Research Centers (TERC) (1990). The National Geographic Kids Network: Year 4 final annual report. (National Science Foundation Grant No. MDR-8652120, October 1, 1989-September 30, 1990). Cambridge, MA: TERC.

Curriculum Evaluation Form

National Geographic Kids Network

Phase I Review

<u>Curriculum Design</u>	<table border="1" style="display: inline-table;"><tr><td>3</td><td>2</td><td>1</td></tr></table>	3	2	1	Average Rating
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Reviewer #1	2.80	2.73			
Reviewer #3	2.66	(Scale 1-3)			
<u>Classroom Design</u>	<table border="1" style="display: inline-table;"><tr><td>3</td><td>2</td><td>1</td></tr></table>	3	2	1	Average Rating
3	2	1			
Reviewer #1	2.35	2.55			
Reviewer #3	2.75	(Scale 1-3)			
<u>Technology</u>	<table border="1" style="display: inline-table;"><tr><td>3</td><td>2</td><td>1</td></tr></table>	3	2	1	Average Rating
3	2	1			
Reviewer #1	3.00	2.68			
Reviewer #3	2.35	(Scale 1-3)			

Phase II Review

<u>Science Content</u>	<table><tr><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr></table>	5	4	3	2	1	Average Rating
5	4	3	2	1			
Reviewer #1	4.41	4.66					
Reviewer #2	4.91	(Scale 1-5)					
<u>Science Process</u>	<table><tr><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr></table>	5	4	3	2	1	Average Rating
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Reviewer #1	5.00	4.50					
Reviewer #2	4.00	(Scale 1-5)					

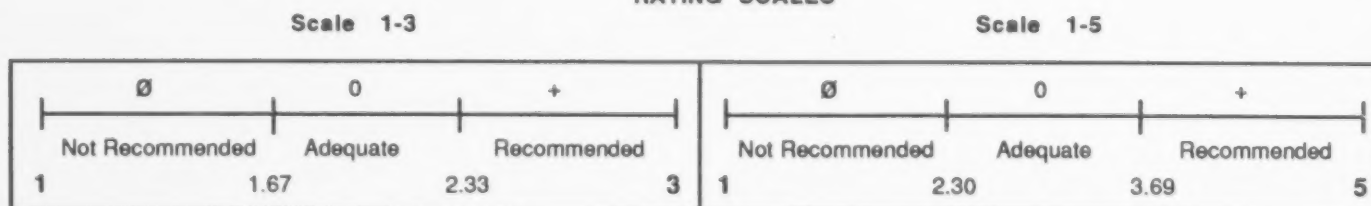
Phase III Review

High Ability Learners	<table><tr><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr></table>	5	4	3	2	1	Average Rating
5	4	3	2	1			
Reviewer #1	3.75	3.04					
Reviewer #3	2.33	(Scale 1-5)					

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
National Geographic Kids Network	2.73 +	2.55 +	2.68 +	4.66 +	4.50 +	3.04 0	

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Science and Technology for Children

Grades 1-6

National Science Resources Center

Smithsonian Institution - National Academy of Sciences

Arts and Industries Building, Room 1201

Washington, DC 20560

(Distributed through Carolina Biological Supply, Burlington, NC)

1991-94

OVERVIEW

Description

Science and Technology for Children (STC) is a set of curriculum units that are organized around scientific topics within the areas of life, earth, physical, and technological sciences. They are being developed by the National Science Resources Center under the joint sponsorship of the Smithsonian Institution and the National Academy of Sciences. The first three units were published in the Spring of 1991; more units are scheduled to be released every six months until 24 units (4 for each grade level) are completed. Each unit consists of a teacher's guide, a set of student activity books, and a kit of materials for carrying out the activities. The three units available at the time of this review are: Plant Growth and Development, Microworlds, and Electric Circuits. Sixteen lessons make up each unit.

Major Program Goals

The foreward of each unit states the following goal:

To provide teachers and children with an inquiry-based curriculum that builds children's excitement as they discover new things and guides them in arriving at explanations that make sense to them.

Research Evidence of Effectiveness

Since Science and Technology for Children is a program that is still being developed, it has not been evaluated for effectiveness. Formative research has been done and has been used for revision purposes. Research on program effectiveness is planned by the developers once the project is completed.

ANALYSIS

General Curricular FeaturesCurriculum design.

The emphasis in each unit of STC is on doing science rather than reading about it or observing it. Hands-on activities are the main vehicle for learning and are well supported by materials that come with the unit. Very little reading is required but can be introduced through the units' extension activities and bibliographies.

Each unit is artfully crafted to cover a single topic in depth. The three units need not be covered in a prescribed sequence; their modular design enables them to be used along with another program where appropriate or to be used together as a complete science curriculum.

Within each inquiry-based unit, activities begin with simple, concrete activities and progress to more complex ones while building on knowledge gained in previous lessons. The promotional materials describe an escalating emphasis on higher-level process skills for upper grade levels. However, it is difficult to judge how successfully they achieve this goal with only three of the anticipated 24 units completed.

Classroom implementation.

STC units are "user friendly" for teachers. They are written in a way that enable teachers with no special knowledge of the topic to do a good job. Teaching strategies and procedures are spelled out in each lesson. Background information and teacher bibliographies are provided. Teachers are urged to respond to difficult questions by modeling the behavior of scientists and asking, "How can we find out?" Each teacher's guide alerts the teacher to valuable hints on classroom management with an icon depicting a hand with string tied around the index finger. Optional workshops for teachers are also available with the purchase of materials.

Each STC lesson requires preparation time to set up the materials. However, since the unit comes with a kit that contains most of the materials, a good deal of time will be saved that might have been spent locating and assembling them.

Students work in small cooperative groups throughout each unit. The activities are the source of much of the content that is learned in each unit; they are not merely verification exercises. The student activity book contains descriptions of all activities as well as some background material. The teacher functions mainly as a facilitator of the groups and as a discussion leader.

STC is rich in assessment materials and ideas. Brainstorming is recommended as an introductory pre-assessment activity but can also be used as a baseline for post-assessment purposes. Assessment activities and materials are included in appendices; none are multiple choice tests. Students are required to keep a notebook to record observations and a folder to house other written work. A Teacher's Record Chart, which is a grid for keeping records on products and skills, is included in an appendix. Authentic assessment is possible since the activities require significant products and/or experimentation. For example, in "Electric Circuits" students are asked to design the wiring and install it in a four-room cardboard "house."

The basic activities of the lessons are good ones and the extensions are superb. For example, after a "Microworlds" lesson on using a microscope, students are asked to use a microscope to determine which postage stamps are printed and which are engraved. Some of these extensions can be set up in a learning station and the teacher's guides make many other suggestions for learning station activities that reinforce unit concepts and promote further knowledge.

Technology.

In spite of the title of this curriculum, no special technology beyond scientific materials and equipment is used in this curriculum. The word "technology" in the title refers to the

technology content that is included in the units such as "Electric Circuits" and "Magnets and Motors."

Exemplary Science Features

Science content.

STC is an exemplary series both in terms of scientific content and students' use of the scientific process. The topics covered are scientifically important and are explored in depth; the science is accurate and presented understandably. Each unit starts out relatively slowly, giving children time to ask broad questions about the subject and to get comfortable with it. By the end of each unit, though, the level of the science is much more complex than it was at the outset and the questions posed are much more challenging.

In terms of content, the units are focused specifically on science rather than on scientific or real-world issues; intradisciplinary and interdisciplinary connections are made as demanded by the science content rather than for any other (such as pedagogical) reason. For example, scientific drawing skills are developed in the microscopy unit, but as scientific skills rather than artistic ones. Emphasis is placed on accuracy of representation rather than on beauty (although beauty is also considered). Similarly, when the students make plant models in the "Plant Growth and Development" unit, more emphasis is placed on accuracy of numbers of parts and on proportions than on beauty or originality. Incidentally, the teacher's guide gives two different sets of directions for students to use when making their plant models. These recipes might better be left unused by gifted learners, as any evaluation of their modeling abilities would be compromised by their having followed a formula rather than creating their own model.

Science process.

The scientific process is well-represented by these units. There are many experimental situations in which the answer is not deducible from a careful reading of the protocol; both the teacher and the students provide unknown samples for analysis; the children are challenged to come up with experimental ways of testing their ideas about various scientific processes. The curriculum is entirely based in the laboratory activities, not on reading or lectures. Students work in small groups both to perform experiments described in the text and to solve relatively open-ended problems such as deducing the arrangement of circuit elements in a closed circuit box. Students are allowed to make mistakes and to learn from them. For example, they are allowed to experiment with circuit elements in such a way that they create short circuits that rapidly drain their batteries and render them useless. Students are told how to detect short circuits and to test batteries to determine whether they are dead. Trial and error is emphasized as a useful way to solve problems, as are brainstorming and cooperative approaches to problem solving. Students are also asked to make real predictions; unlike the "predictions" required by other curriculum packages, these are informed by the students' experimentally derived understanding of the problem under study, rather than being blind, uninformed guesses.

Tailoring for Special Populations

Differentiation for high ability learners.

STC would be a rich supplement to any basal text. Even though it would benefit all learners, it contains special opportunities for high ability students to explore scientific content beyond the basics.

These units are appropriate for use in a pull-out program or other self-contained enrichment programs for high ability learners. In one of these settings teachers could concentrate on the most open-ended activities. There are a sufficient number of resources included or suggested in the units to challenge any student. However, if the class is heterogeneous, regrouping for some activities would be advisable to allow high ability students to work together on the most challenging extension work.

Significant topics are covered in sufficient depth to be gratifying to a high ability or science-prone student. However, since the activities increase in complexity over the course of the 16 lessons within each unit, it is imperative that a teacher allow enough time to complete the entire unit. The most challenging activities occur in later lessons in the unit and in the extension suggestions. Early lessons could be compressed somewhat but the hands-on nature of the lessons requires ample time.

STC does a nice job in setting up a laboratory environment in the classroom. To maintain that setting for extension work and to preserve the possibilities for small group work, additional time should be budgeted for extension activities within the classroom. These are often open-ended opportunities that use creative and high level thinking skills that are required to challenge high ability learners. For example, in an extension of lesson 16 of "Electric Circuits" students are asked to wire a room with two doors and one light so that either switch controls the light. In a "Microworlds" extension students are asked to plan and carry out a controlled experiment to find out what happens to algae deprived of light. It would be unfortunate to exclude these because of lack of time.

Though not suggested by the materials, the teacher might also use some extension activities as an opportunity to link gifted students with a mentor.

Other special populations.

This curriculum contains no special features that are particularly advantageous to girls, minorities, or disabled students.

CONCLUSION

Science and Technology for Children is designed well for in-depth coverage of significant science and technology concepts as well as a rich experience in scientific process. It would provide valuable enrichment to any existing science program. It also contains a sufficient number of experiences in extended content and higher level thinking skills to make it appropriate for gifted learners. While it lacks the strong emphasis on the "real world" that many of the other new curriculum packages stress, it might be especially attractive to science-prone gifted students, as it provides unusual scientific depth in a strongly scientific atmosphere.

Curriculum Evaluation Form

Science and Technology for Children

Phase I Review

Curriculum Design

3	2	1
---	---	---

Average Rating

Reviewer #1

2.86

2.82

Reviewer #3

2.78

(Scale 1-3)

Classroom Design

3	2	1
---	---	---

Average Rating

Reviewer #1

2.9

2.95

Reviewer #3

3.0

(Scale 1-3)

Technology

3	2	1
---	---	---

Average Rating

Reviewer #1

NA

NA

Reviewer #3

NA

Phase II Review

Science Content

5	4	3	2	1
---	---	---	---	---

Average Rating

Reviewer #1

3.92

3.84

Reviewer #2

3.75

(Scale 1-5)

Science Process

5	4	3	2	1
---	---	---	---	---

Average Rating

Reviewer #1

3.93

3.86

Reviewer #2

3.79

(Scale 1-5)

Phase III Review

High Ability Learners

5	4	3	2	1
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Average Rating

Reviewer #1

3.58

4.13

Reviewer #3

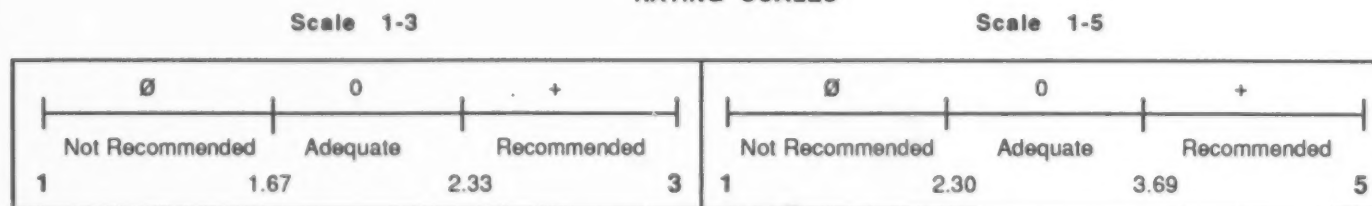
4.67

(Scale 1-5)

Consumer's Guide Rating Form

Title of Materials	Scale 1-3			Scale 1-5			Notes
	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	
Science & Technology for Children	2.82 +	2.95 +	NA	3.84 +	3.86 +	4.13 +	A, B

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Section IV Supplementary Materials

Supplementary materials are comprised of loosely connected activities or fully developed units that enrich existing curriculum. These materials generally have a very precise focus, rather than a comprehensive treatment of science subject matter. Materials reviewed in this section range from print activities, such as the AIMS program, to technology-based explorations of machines and engineering in Lego TC Logo to an investigation into the nature of scientific habits of mind in The Search for Solutions.

List of Reviewed Materials

Activities to Integrate Mathematics and Science (AIMS)

Challenge of the Unknown

LEGO TC Logo

Search for Solutions

Students and Research

Teaching Integrated Math and Science (TIMS)

Voyage of the Mimi

Activities to Integrate Mathematics and Science (AIMS)**Grades K-9**

AIMS Education Foundation

P.O. Box 81200

Fresno, CA 93747

1982 to date

OVERVIEW**Description**

Activities to Integrate Mathematics and Science (AIMS) seeks to integrate mathematics and science as disciplines and then to link mathematics and science with other curriculum areas, especially language arts and social science. Currently, the program consists of twenty-six activity books that include lesson plans and black-line duplicating masters. The books span various grade levels. Books include K-1: "Fall Into Math and Science," "Glide Into Winter With Math and Science," "Spring Into Math and Science," "Primarily Plants," "Primarily Physics, Book A and B," are the titles for grade two units. The K-6 series includes "Water Precious Water," and "Critters." Titles in the grades 3-4 series include: "Jaw Breakers and Heart Thumpers," "Hardhatting in a Geo-World," "Popping With Power," and "Overhead and Underfoot." For grades 5-9 there is "Math + Science, A Solution," "The Sky's the Limit," "From Head to Toe," "Fun With Food," "Floaters and Sinkers," "Down to Earth," "Our Wonderful World," "Pieces and Patterns, A Patchwork in Math and Science," "Out of This World," "Soap Films and Bubbles," "Mostly Magnets," and "Finding Your Bearings."

AIMS offers a variety of laboratory materials to support the activity books. They supply cups and spoons, liter boxes, balances, and thermometers for measuring volume, mass, and temperature. Their "Gramstackers," a set of color-coded, hexagon-shaped stacking blocks, provides a set of weights in gram units. The types of small, plastic bears serve as manipulatives for counting, patterning, and solving other math problems. The magnet lab, designed specifically to supplement the "Mostly Magnets" unit, includes a variety of magnets and scales.

Major Program Goals

The AIMS program has four principal objectives:

1. To improve student understanding of mathematics and science concepts and their interrelatedness while at the same time developing a strongly positive attitude toward the study of these disciplines.
2. To train classroom teachers to assume leadership roles in their districts by providing staff development in mathematics and science.
3. To assist teachers to change the way they teach mathematics and science by using a hands-on, integrated approach.
4. To provide sound integrated math/science curricular experiences consistent with the recommendations of Project 2061 and NCTM standards.

Research Evidence of Effectiveness

AIMS Director, Arthur J. Wiebe, Ed.D., Supplied the evidence of effectiveness for this review. His correspondence included the following measures of effectiveness for each of the above objectives.

1. Although no formal study has been done to determine whether AIMS improves student understanding of mathematics and science concepts, feedback indicates that interest is high during AIMS activities.
2. To date 300 teachers have completed the AIMS National Leadership Program which leads to qualification as an AIMS instructor. Instructors are monitored by AIMS staff and evaluated by workshop participants.
3. The increasing number of workshops that school districts request and the positive response of participants was cited as evidence of assisting teachers to change the way they teach mathematics and science.
4. AIMS' fourth objective is achieved through the development and dissemination of AIMS publications. Dr. Wiebe cites growing demand for the publications as evidence of effectiveness.

ANALYSIS

General Curricular Features

Curriculum design.

Project AIMS materials omit many elements of a fully developed curriculum and therefore cannot be evaluated as such. However, the extensive materials contain both advantages and disadvantages for science curriculum development that are worth considering.

The program lacks a carefully developed scope and sequence which precludes in-depth coverage of significant science content. For instance, physics topics are introduced in "Primarily Physics" at the primary level with activities such as paper cup telephones, musical bottles, and melting ice cubes. Physics topics are then scattered throughout other books such as "Popping With Power" for grades 3-4 and "Mostly Magnets" for grades 2-8. However, it is difficult if not impossible to find a coherent or comprehensive treatment of the physics topics of motion and force, energy, machines, electricity, light, and sound.

Generally, the AIMS books contain only a chart that lists each activity along with the science processes and math skills that are addressed by that activity. The Mostly Magnets book, however, provide a conceptual overview that discusses the theme of the book and identifies the science content which the activities demonstrate. In addition, ten pages of information about magnets conclude the book. This conceptual overview and background information is needed in all of the books to help students and teachers connect activities with content and purpose.

Curriculum implementation.

Each topical AIMS book contains 15-25 activities or investigations. The detailed lesson plan for each of the activities includes twelve sections: a listing of math and science topic areas covered by the activity, an introductory statement, a listing of math skills and science processes contained in the activity, a list of materials, a key question that frames the activity, several paragraphs of background information, management tips, a step-by-step procedure, discussion questions, a list of Blackline masters that serve as student information pages or worksheets then follow the lesson plans. The books are bound so they can be torn apart for easy duplicating.

The Project AIMS activities emphasize skills, concrete experiences, and playful exploration. Students work either independently or in small groups. Illustrated with cartoon drawings, the activities and worksheets are designed to capture students' interest.

Teacher-led discussion is a key feature of each activity, with questions for discussion specifically stated. However, the lack of a discussion model provides teachers with a closed set of questions rather than examples and a guide for stimulating discussion.

The "curriculum coordinates" that are suggested for integrating language arts, social studies, art, and/or music are related to the topic of study, but do not necessarily increase understanding of either science or the other discipline. For instance, building an igloo from sugar cubes as an art activity when studying insulation and refrigeration neither builds science concepts nor relates art to science in a meaningful way. Instead, it becomes an activity for the sake of an activity.

Measures of student progress are neither provided for nor suggested. Again, the topical books contain discrete activities with no stated progression of skill development or content understanding. Because the activities are not linked to one another by broad instructional outcomes, assessment of student growth and understanding would be difficult.

Technology.

The AIMS books do not utilize technology. The activities are based on readily available materials.

Exemplary Science Features

The title of this program--Activities to Integrate Mathematics and Science--should alert educators to the fact that the program manuals are collections of activities and not fully-developed curriculum guides. The activities are designed to supplement curriculum, not define it. Therefore, each activity must be evaluated individually as to its value and how it achieves local curriculum goals. Otherwise, the activities serve superficial purposes and lose their potential effectiveness.

The activities offer canned experiments that tend to demonstrate facts and isolated skills rather than allowing for true scientific inquiry. The two-page experiments often supply the answers instead of challenging students to question and discover on their own. In some instances, the activities fail to present the scientific process accurately. For instance, "predict" is generally used as a synonym for "guess;" students are not asked to base their predictions on prior experiences or to justify their guesses. Predicting then becomes an isolated, unrelated skill rather than a search for patterns or understanding.

Tailoring for Special Populations

Differentiation for high ability learners.

The individual activities that are framed by narrow, specific tasks force students and teachers to focus on discrete facts and experiences rather than broad content or conceptual themes. AIMS activities offer opportunities to practice basic skills, they do not stress the complex concepts nor the synthesis of skills that challenge gifted learners.

AIMS materials are most useful to teachers who have a curriculum framework and who are looking for activities that develop skills or illustrate content facts. When the AIMS activities are carefully selected, some of them can be used to initiate independent investigations by gifted learners or to serve as extension activities. To be meaningful, the activities must be carefully integrated into a larger, well-planned study.

Other special populations.

With language and illustrations, the AIMS materials carefully include girls and minority students. In addition, the AIMS National Leadership Program is particularly concerned that women assume a major leadership role. Seventy-five percent of the teachers who have successfully completed the seven-week training course are women

CONCLUSION

The title of the program, Activities to Integrate Mathematics and Science, captures its essence. The books offer an array of activities on diverse topics for students in kindergarten through ninth grade. The program offers a useful resource for locating hands-on activities to strengthen skills in mathematics and science and to demonstrate the use of mathematics in scientific investigation. The AIMS materials serve as a supplementary resource, not a curriculum.

To use the AIMS program successfully, teachers must link the self-contained activities to meaningful content and broad concepts. The program does not provide students with insight to the ambiguities of science nor allow them to experience the complexities of the scientific process.

Curriculum Evaluation FormAIMSPhase I ReviewCurriculum Design

3	2	1
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Average Rating

Reviewer #1

1.46

1.52

Reviewer #2

1.58

(Scale 1-3)

Classroom Design

3	2	1
---	---	---

Average Rating

Reviewer #1

1.53

1.54

Reviewer #2

1.54

(Scale 1-3)

Technology

3	2	1
---	---	---

Average Rating

Reviewer #1

NA

NA

Reviewer #2

NA

Phase II ReviewScience Content

5	4	3	2	1
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Average Rating

Reviewer #1

1.75

1.65

Reviewer #2

1.55

(Scale 1-5)

Science Process

5	4	3	2	1
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Average Rating

Reviewer #1

1.43

1.72

Reviewer #2

2.00

(Scale 1-5)

Phase III ReviewHigh Ability Learners

5	4	3	2	1
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Average Rating

Reviewer #1

1.25

1.42

Reviewer #3

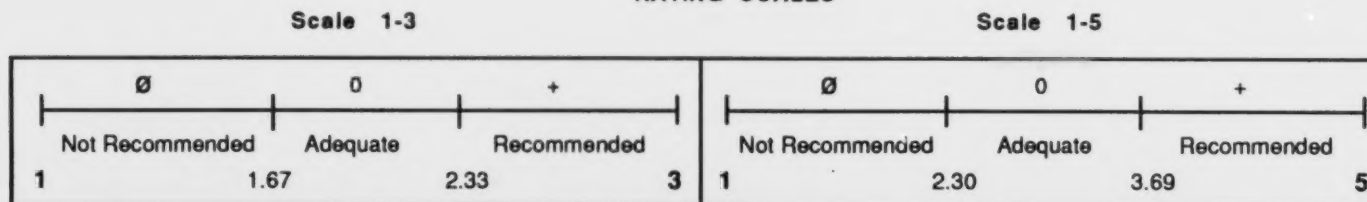
1.58

(Scale 1-5)

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Activities in Math and Science (AIMS)	1.52 +	1.54 0	NA	1.65 0	1.72 0	1.42 0	

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

The Challenge of the Unknown
 Funded by Phillips Petroleum
 Distributed by Karol Media
 P.O. Box 7600
 Wilkes-Barre, PA 18773-7600
 1986

Grades 4-8

OVERVIEW

Description

The Challenge of Unknown is a problem solving program that organizes problems around seven themes: situation, information, restatement, outcomes, management, estimation, and argument. Applications of each type of problem are illustrated in a set of videotapes. The seven 25-minute video presentations include comedy segments as well as documentaries that show problem solving in the real world. A Teaching Guide contains background information, problems, activities, and suggestions for implementing Challenge in the classroom. An additional set of 16 Teaching Notes is also available with more expected to be published; they present further examples and applications for both Challenge and Search for Solutions.

Major Program Goals

The Teaching Guide states the following goals:

- 1) To break down students' negative stereotypes about mathematics; and
- 2) To offer a new way for them to think about math, which is at once useful and enjoyable.

Research Evidence of Effectiveness

No research evidence of effectiveness is available for The Challenge of the Unknown.

ANALYSIS

General Curricular Features

Curriculum design.

Challenge of the Unknown is a program that is based on thinking processes rather than on content. It attempts to improve problem solving skills by showing students real people, often scientists and engineers, who are engaged in significant tasks involving problem solving. It is successful in avoiding stereotypical "textbook" problems and features the symbiotic relationship between science and mathematics. Examples are: prospecting for wind as a power source, estimating a population of sharks, and using physics and mathematics to demolish a hotel.

Video segments are the springboard of the curriculum. They spark the interest of students while conveying powerful examples of an abstract way of organizing ideas. Concrete examples of scientific problem solving are shown in the films. The theory behind some of the scientific

principles is supplied in the Teaching Guide for use in follow-up activities. These theoretical explanations mainly concern applications of physics and include the following: How sonar works, why a boomerang comes back, life and drag, leverage, and the Magnus Effect.

No scope and sequence is stated for this program. The Teacher's Guide tells users to "fit Challenge of the Unknown into your curriculum where you think it appropriate." Segments of the material can be used in any order. No materials such as textbooks, workbooks, worksheets, or manipulatives are included for student use. The preface of the Teaching Guide describes the guide as a catalog since "you shop it for help"; as a toolbox containing tools to help students unlock creativity; as a defensive manual containing material needed to respond to students' questions; and as an offensive manual to help students get involved with problem creation and solving.

Classroom implementation.

No formula for implementation is provided. Challenge is designed to be a flexible resource rather than a script. If this program is used in conjunction with both math and science basal texts, it will provide not only a link between the two subjects but also an artful depiction of applications of both.

Many opportunities are suggested for active problem finding and solving and for activities that engage students in the type of problem solving process used in science. Small group and hands-on activities are suggested that reinforce problem solving themes and skills. Discussions and activities are necessary to internalize the problem solving process. Questions are furnished for discussion both before and after each film. Some excellent models of teacher-student dialogues are included in which students are encouraged to create their own problems. The problems that are included with each section vary greatly in the level of difficulty. Since the material is designed to be used with a wide spectrum of ages and ability levels, teacher selection of problems and other activities beyond the video segments is necessary to suit the needs of the particular students. It is likely that no two classrooms would have the same experience due to differences in choices by the teachers.

No assessment instruments are included or suggested with this program. A bibliography is included with a background extension material for students as well as background resources for teachers. There are also exercises that could be adapted as individual extension activities for students. For instance, the "Restatement" segment of the videos shows scientists using a computer program that generates geometric patterns called fractals to model vegetative cycles in the Okefenokee Swamp. A similar computer program is listed in the Teaching Guide and could be given to students for open-ended investigation of how it works and further applications.

Since Challenge of the Unknown is not a full year curriculum, it could be used as a math and science interdisciplinary unit for a portion of the school year or selected portions could be used to supplement other science curriculum units. In a heterogeneous class, low ability students would likely need additional assistance from the teacher or other students as the thematic connections are abstract. Since there are varying difficulties in the suggested exercises and activities, the teacher can tailor the choice of these to fit the needs of small groups or individuals. The role of the teacher as explainer, definer of themes, and discussion leader is critical since the films do not define or explain, but illustrate by example. The teacher is the key to unlocking the power of the materials.

Technology.

There is no special use of technology in this curriculum beyond the videotapes. The video segments are masterfully done and provide examples of scientific process that might not otherwise be accessible to students. They also demonstrate examples of technology at work, such as the use of sonar as a means to locate fish.

Exemplary Science Features

Science content.

The scientific content of Challenge of the Unknown is not broad in scope or deep in coverage of concepts. It is not designed as a science curriculum and was not intended to be a primary source of facts and concepts. A strength of the program is in its portrayal of scientific process in terms of problem solving in the real world. Applications of science that are used in Challenge include harnessing energy from the wind, creating artwork by reflecting sunlight from mirrors, studying lift and drag as it affects speed skiers and ski jumpers, locating fish with sonar, determining the running speed of dinosaurs, studying vegetation growth of the Okefenokee Swamp, estimating the shark population in the Bimini Lagoon. Using gravity and vectors to demolish a building, improving the distance flown by a boomerang, hypothesizing about the significance of the monoliths of Stonehenge, determining whether the cave spirals of the Anasazi Indians were seasonal markers, and redesigning the dirigible are also included. A good balance is maintained between descriptive presentations of how and why these activities are carried out, and follow-up activities involving computation or graphing work to support them. The topics give a good sense of how the frontiers of science are moved forward even though some of the problems may not be as current as they were when the videos were produced.

Science process.

Challenge portrays science as a real-life activity in which boundaries are often nearly indistinguishable from other content areas such as mathematics, social studies, and art. Scientific process is mainly observed rather than practiced in the curriculum. Students are not asked to do scientific experiments. Instead they are asked to solve problems that may be framed in scientific context, or asked to model supportive activities such as estimation by tag and recapture. The lack of hands-on scientific experiments might seem to be a deficiency in the curriculum but Challenge is not designed to fulfill that aspect of science education.

Tailoring for Special Populations

Differentiation for high ability learners.

Challenge of the Unknown is a curriculum that would be of great benefit to high ability learners. Unlike basal texts it avoids emphasis on basic facts, skills, and concepts and instead focuses on a view of problem solving as a valuable real life process. This viewpoint is illustrated in the meaningful activities of adult role models in the videos. The organization of problems by non-standard problem solving themes (situation, information, restatement, outcomes, management, and argument) requires the ability to deal with abstract concepts and to analyze, synthesize, and evaluate new information in terms of these themes. Challenge models a way to organize ideas,

and encourages higher level thinking skills and the transfer of abstract concepts to new situations.

Challenging exercises and activities are included to foster creativity. Articles in the Teaching Guide may be copied for student use. They are written on an advanced reading level and contain challenging vocabulary. The resources suggested in the bibliographies would also be appropriate for high ability readers as well as teachers.

This curriculum is an ideal curriculum to use with a self-contained group of high ability learners. They will be able to thoroughly develop the resources available and should be encouraged to create an advanced product as a result of their experiences in the program. If Challenge is used in a heterogeneous classroom, the teacher should strive to maintain a high level of critical thinking in discussions and should direct the more challenging activities to high ability learners. Some activities could be set up in learning station format as extension work, but the video and discussion portions are a necessary prerequisite.

Other special populations.

The videotapes include several segments that feature female scientists. A black engineer appears in "New Keys to Old Locks." No features that are particularly advantageous to disabled students are included.

CONCLUSION

The strengths of The Challenge of the Unknown lie in its interdisciplinary portrayal of the problem solving process as a meaningful and useful skill. It teaches students to search out and solve problems without emphasis on getting the "right answer." It promotes decision making and a philosophy of life-long learning. Even though these goals are desirable for all students, Challenge conveys the message with a level of abstraction that is appropriate for high ability and gifted learners.

Curriculum Evaluation Form

Challenge of the Unknown

Phase I Review

Curriculum Design

3	2	1
---	---	---

Average Rating

Reviewer #1

2.56

2.62

Reviewer #3

2.67

(Scale 1-3)

Classroom Design

3	2	1
---	---	---

Average Rating

Reviewer #1

2.18

2.51

Reviewer #3

2.83

(Scale 1-3)

Technology

3	2	1
---	---	---

Average Rating

Reviewer #1

2.69

2.69

Reviewer #3

2.69

(Scale 1-3)

Phase II Review

Science Content

5	4	3	2	1
---	---	---	---	---

Average Rating

Reviewer #1

3.75

3.88

Reviewer #2

4.00

(Scale 1-5)

Science Process

5	4	3	2	1
---	---	---	---	---

Average Rating

Reviewer #1

3.21

3.93

Reviewer #2

4.64

(Scale 1-5)

Phase III Review

High Ability Learners

5	4	3	2	1
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Average Rating

Reviewer #1

3.91

4.16

Reviewer #3

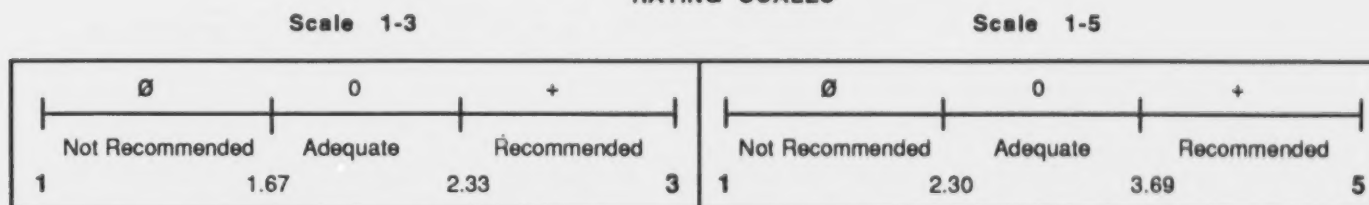
4.41

(Scale 1-5)

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Challenge of the Unknown	2.62 +	2.51 +	2.69 +	3.88 +	3.93 +	4.16 +	A

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

LEGOTC Logo
 Lego Dacta
 555 Taylor Road
 Enfield, CT 06082
 1989

Grades 4-12

OVERVIEW

Description

LEGO TC Logo combines the familiar children's LEGO brick construction materials with a computer and the Logo programming language. Using the materials, children construct machines with motors and sensors then program the machines to perform several functions. LEGO TC Logo is a hands-on building and computer programming opportunity that enables children to invent and explore.

The LEGO TC Logo Starter Pack designed for elementary and middle school students includes a teacher's guide, a computer set-up guide, student guides, LEGO TC software, a set of over 450 LEGO building elements, an interface box and transformer, and a computer slot card. The second set called Technic Control I Technology Pack contains more advanced components and a resource guide for middle school and high school students.

The LEGO TC Logo Starter Pack is divided into three projects: Getting Started, Making Machines, and Teaching the Turtle. For each project, there is a student booklet that provides background, an explanation of concepts, step-by-step instructions for working with the computer, and suggestions of "challenge" activities. Activity cards that are similar to the graphic instructions found in commercial LEGO sets provide students with instructions for building the sample machines. A teacher's guide provides background for the three projects and suggestions for developing concepts.

Software for the programs is available for both Apple and MS-DOS compatible computers. LEGO Dacta offers the following technical support for using the equipment: training; assistance with proposal writing for funding; and the LEGO Dacta Connexion, a user group for LEGO TC Logo. The LEGO Dacta Connexion newsletter contains curriculum ideas, news about projects, and a directory of members to facilitate communication.

Major Program Goals

Overall goals and objectives are not stated in the LEGO TC Logo Teacher's Guide. A curriculum chart rather than a statement of goals and objectives correlates LEGO TC Logo skills and concepts with science concepts, math concepts, and social studies ideas. Throughout the program, the LEGO TC Logo skills and concepts receive explicit attention whereas the science, math, and social studies concepts are suggested, not developed.

Research Evidence of Effectiveness

Lai (1990) documented a specially designed Lego-Logo learning environment then studied the cognitive and metacognitive outcomes, the attitudes of participants toward the Lego-Logo learning environment, and gender differences in computer use. The study spanned an eight-

week session (one and a half hours each) and included 15 boys and 9 girls (aged 10 to 11). The specially designed Lego-Logo learning environment contained four elements: (1) participants were encouraged to use a four-step problem solving method, (2) participants were given explicit instruction in metacognition, (3) a small-group cooperative where participants rotated the four major roles of model builder, programmer, questioner, and record keeper, (4) an active, constructivist learning process where the teacher encouraged the participants to ask questions and to monitor their progress. Lai concluded: (1) that the Lego-Logo learning environment in the study was highly motivational to young learners, (2) that no gender differences were evident, and (3) that the learning environment was conducive to acquisition of knowledge in control technology, skills in problem solving, and metacognition, and cooperative learning. Lai recommended that further research investigate the transfer of problem-solving skills and how the learning environment could be integrated into existing primary school curriculum.

ANALYSIS

General Curricular Features

Curriculum design.

The LEGO TC Logo instructional materials stress the value of discovery learning by allowing children to construct and design according to their own pace and style. The explicit curriculum content includes Lego constructions, the Logo computer language, and using the Logo language to control LEGO constructions. The teacher's manual then includes ideas for curriculum correlation and extensions which can be developed by the teacher.

Examples of science concepts that teachers can develop when using LEGO TC Logo include simple machines, motion, friction, light, color, animal senses, machine sensors, and centrifugal force. Within the program, teachers can build on math skills such as measuring, averaging, and graphing that students employ as they construct and program. Binary arithmetic, recursion, fractions, ratios, and logic are examples of other math concepts that can be developed. The curriculum accommodates related social studies topics such as invention and inventors, the industrial revolution, transportation, communication, and technology of the future. Project management is yet another implicit concept within the curriculum that can be developed.

Classroom implementation.

According to the teacher's manual, the LEGO TC Logo Starter Pack requires at least 30 hours of classroom time. The projects accommodate a variety of settings: total class instruction, small group work, center work, and enrichment classes outside of school. Student manuals and activity cards guide students through initial, structured projects that establish competency for further self-directed exploration.

LEGO TC Logo is not designed as a classroom curriculum that links objectives, activities, and assessment. Rather, the materials and tools provide students opportunities to construct models in order to gain insight into technology, especially robotics and computer technology. The materials are designed for a workshop setting in which students work in pairs to build, experiment, test, and redesign their inventions.

The teacher acts as a facilitator by introducing projects, encouraging brainstorming, leading discussion, and probing for understanding. Typical questions that are suggested to assist students in building problem solving skills include: "What seems to be the problem?" "How have you tried to fix it?" "Let's try to figure out why it's not working." Repeatedly, teachers are encouraged to restrain themselves from the impulse to teach concepts and to offer LEGO TC Logo as a language learned by use and experience.

Evaluation procedures are not provided in the LEGO TC Logo program. Broad categories for evaluation such as of group work, individual work, divergent thinking, convergent thinking, hands-on, and "heads-in" are listed as possibilities but are not developed. Again, the LEGO TC Logo instructional materials lack standard curriculum components and must be supplemented with teacher-developed materials.

Technology.

In this program, technology is the content, the process, and the product. Students use LEGO building blocks, gears, motors, lights, and sensors to design and construct; then they use Logo computer programming and word processing to control their constructions, solve problems, and write reports.

The computer user manuals and support materials that accompany the program are straight forward and easy to use. A set-up guide provides complete instructions for the installation of the computer software. The student activity cards and booklets provide basic Logo programming information complete with "bug box" inserts to help students locate the "bugs" in their programs. The materials encourage problem solving and independent work.

Exemplary Science Features

Science content.

The hands-on work of LEGO TC Logo provides students with an intuitive understanding of basic physics concepts such as work, mass, acceleration, and friction. In this program, students have the opportunity to experience and use concepts before they hear the technical vocabulary that describes the concepts. The teachers' manual suggests ways to amplify and extend the content of the activities. For instance suggestions to the teacher in the "Smart Cars" activity, include taking apart an analog clock and looking at electric meters to see gears in the "real world." In addition, there is extensive information for the teacher that explains "mechanical advantage."

Teachers in Anock-Hennepin County (Minnesota) School District extended the content of LEGO materials by writing a Simple Machines Curriculum. Marketed by LEGO, the lesson plans based on the Madeline Hunter Model address concepts such as force, potential energy, and kinetic energy. The unit can be used to supplement the content of the LEGO TC Starter Pack and to provide additional instructional strategies.

Science process.

LEGO TC Logo is a process curriculum where students direct their own learning. Students engage in the metacognitive and creative problem strategies of problem finding and defining,

generating ideas, finding solutions, evaluating possibilities, and developing a plan. Students receive immediate feedback on their efforts through the success or failure of their working model.

The program encourages teachers to act as coaches to student learning by being a catalyst, a discussion leader, and a consultant. The teacher's manual suggests that each student keep an "Inventor's Notebook" to write down or draw ideas for projects, keep data on experiments, and to make "LEGO TC Logo Patents."

Tailoring for Special Populations

Differentiation for high ability learners.

Because of the opportunities it offers for open-ended investigation and invention, LEGO TC Logo is especially appropriate for high ability learners. In addition, the interdisciplinary curriculum which centers on problem-based learning can be tailored to meet individual and group interests.

The LEGO TC Logo program offers ready-to-use enrichment activities for gifted learners. The materials can be set up easily in centers for students to use as time allows. Gifted learners can then work unimpeded to develop complex mechanisms.

In addition, the program can be used as a spin off to challenge gifted learners to explore concepts in various disciplines such as centrifugal force, binary arithmetic, logic, communication, and the history of machines. For this expanded program, teachers must develop their own materials. Suggestions that can act as springboards for students and teachers are given within the teacher's manual.

Other special populations.

The hands-on experiences with technology coupled with the opportunities for discussion and collaborative teamwork that LEGO TC Logo offers complements the learning styles of girls and minority students. In addition, girls and minorities may have limited experiences with construction materials such as LEGO components and with computer technology. The self-directed work of LEGO TC Logo allows students time to experiment and to start with projects that interest them.

CONCLUSION

LEGO TC Logo is a unique program that offers students the opportunity to build machines and to control them with a computer. A major strength of the program is the opportunity it affords students to develop independent problem solving skills. In addition the materials offer experiences with complex physics and mechanical concepts.

Based on a philosophy of "silent teaching," the LEGO TC Logo program does not provide teachers with the standard curriculum components of objectives and assessment measures. Instead, the program offers guided student projects and encourages students to create their own personal projects which are modifications of the guided projects or totally new inventions.

The flexible LEGO TC Logo program can be used to meet the needs of various age and ability groups. With little direct instruction, students can use the materials independently and at their own pace. The allure of "I can make it work" may motivate low-achieving students as well as advanced problem solvers.

REFERENCES

- Lai, K. (1990). Problem solving in a Lego-Logo learning environment: Cognitive and metacognitive outcomes. In A. McDougall & C. Dowling (Eds.), Computers in Education (pp. 403-408). Holland: Elsevier Science Publishers.

Curriculum Evaluation FormLEGO TC LogoPhase I ReviewCurriculum Design

3	2	1
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Average Rating

Reviewer #1

2.75

2.75
(Scale 1-3)Classroom Design

3	2	1
---	---	---

Average Rating

Reviewer #1

2.15

2.15
(Scale 1-3)Technology

3	2	1
---	---	---

Average Rating

Reviewer #1

3.00

3.00
(Scale 1-3)Phase II ReviewScience Content

5	4	3	2	1
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Average Rating

Reviewer #1

3.00

3.43

Reviewer #2

3.85

(Scale 1-5)

Science Process

5	4	3	2	1
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Average Rating

Reviewer #1

3.29

3.78

Reviewer #2

4.27

(Scale 1-5)

Phase III ReviewHigh Ability Learners

5	4	3	2	1
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Average Rating

Reviewer #1

3.42

4.21

Reviewer #3

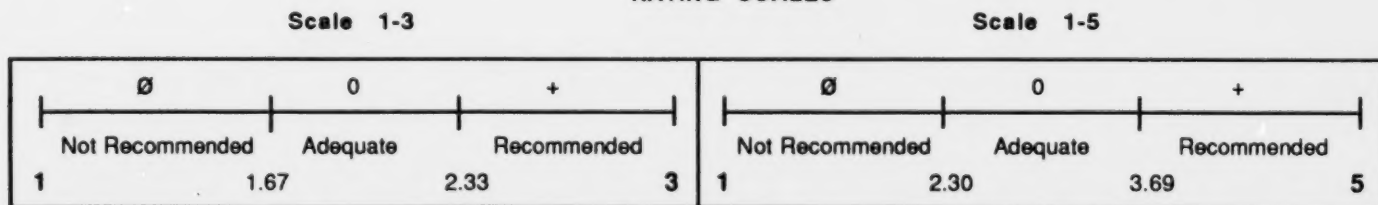
5.00

(Scale 1-5)

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
LEGO Logo	2.75 +	2.15 0	3.00 +	3.43 0	3.78 +	4.21 +	A, B, C, D

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Search for Solutions

Grades: Middle/Secondary

Funded by Phillips Petroleum

Videotapes distributed by Karol Media

350 North Pennsylvania Avenue, P.O. Box 7600

Wilkes-Barre, PA 18773-7600

1979

OVERVIEW

Description

Search for Solutions is not designed to be a standard, full-year curriculum. It is a program that illustrates nine major themes in science using both historical and contemporary examples. The nine themes are: prediction, modeling, theory, evidence, patterns, investigation, adaptation, trial and error, and context. A videotape documentary series makes up a major part of the program. It is accompanied by three brief film guides that introduce each theme and suggest follow-up activities. A series of 16 Teaching Notes, containing additional examples and ideas for activities are available upon request from Karol Media. Additional Notes are planned to be produced every six months beginning this year. The book on which the series is based is Search for Solutions, by Horace Freeland Judson. This paperback book is available separately from the Johns Hopkins University Press.

Major Program Goals

In the preface of his book Judson states, "The aim of this book is to ransack the enormous disparity of the sciences for instances that display some underlying unities of approach that bring us such reliable knowledge." The films and activities are consistent with this objective. No other goals or objectives for the films or overall program are stated.

Research Evidence of Effectiveness

No research evidence of effectiveness is available for Search for Solutions.

ANALYSIS

General Curricular FeaturesCurriculum design.

Search for Solutions organizes scientific knowledge by broad themes rather than by topic. The intent is not to convey facts or in-depth knowledge about the concepts. Instead, Search for Solutions was designed to make students think about scientific ideas, their development, their applications, and their future. Since it was not designed as a traditional curriculum, it lacks such features as instructional objectives, detailed implementation instructions, and assessment strategies. Similarly, it does not emphasize the use of hands-on materials or scientific experimentation. The sole purpose of the series is to provide a sophisticated look at science and people who use science. The companion book, Search for Solutions is written for adults.

Classroom implementation.

This program is not appropriate for use by inexperienced teachers. No outlined procedure is included for implementation beyond a suggested "Getting Started" discussion or activity and a few follow-up activities. The Teaching Notes contain additional activities and articles on supplemental topics that support the themes that are identified in the videos. No discussion questions or handout materials are included. Any teacher who wishes to use this material needs to determine his/her own objectives and to determine the best use of the readings from the book. The teacher will also have to locate, pull together, and perhaps create some activities or design a discussion model. If the video portions are shown without use of adequate integration of meaningful student-centered activities, the program will lose a great deal of its potential. Bibliographies are included that support the film topics but the entries may be out-dated due to the age of the films, which were made in 1979. Some opportunities for independent extension work are included, but teachers will have to identify them since nothing is labeled as an "extension." Further ideas for activities, such as writing assignments, will suggest themselves to an experienced teacher due to the richness of the subject material.

Search for Solutions would not work well with low ability students since there is a high level of abstraction in concepts. Even with high ability students the program cannot be used as a stand-alone independent study project since the films and discussions are key components. However, some extension activities could be done individually. For example, an activity in the Teaching Notes asks students to design a structure that is earthquake resistant. Learning center activities would have to be developed by the teacher as few ideas presented in the materials are suitable as given for that purpose.

Technology.

The video portions of Search for Solutions dramatically inspire interesting ways of thinking about the interconnectedness of scientific topics under broad themes such as modeling or patterns. They provide a glimpse of experiences that would be outside the reach of most students. Examples are: a visit to a model rain room in Japan, an explanation of crystalline structures by Nobel Prize winner Linus Pauling, a ride in a hot air balloon, and a view of the mosaics in Moorish temples in Granada, Spain. No specific uses of technology by students are employed in the program.

Exemplary Science Features

Science content.

The Search for Solutions program is not a science curriculum per se; it is more like a "history of science ideas" program. It has been designed to illuminate important general aspects of the scientific process by means of examples drawn from the history and philosophy of science. The building of theories, the acquisition of facts, the use of models, and other broad features common to all science are illustrated by many well-chosen examples. As the series was produced in 1979, all of the examples are now historical while at the time they were leading edge. Nonetheless, they do a fine job of illustration, as intended.

Because of the focus of the series on the broad aspects of science, no single scientific content area can be covered in depth. The series might therefore be more appropriate for older or more

sophisticated learners. For example, a student who had no idea who Linus Pauling is or what a protein is might be unimpressed by Pauling's reminiscences about the development of the idea of the alpha helix, while a student with more background would understand the seminal nature of Pauling's contributions and pay more (well deserved) attention. The more students bring to this series, the more they are likely to get out of it; this applies equally to the book and the videotapes.

Science process.

The series does a fine job of illustrating the intellectual aspects of the scientific process. The videotapes show real scientists talking about their science and show science in progress. Many important issues in science and major research areas are touched on both in the videotapes and in the book; an amazing number of the examples are still important areas of scientific research even twelve years after the series was produced. The potential for hands-on science for the learner is somewhat less impressive. The only suggested activities are found in the Teaching Notes. While a number of the activities would be enjoyable and would illustrate abstract aspects of the scientific process (such as the use of models), many of them do not involve scientific topics. Rather they apply methods of thinking used by scientists to areas outside of science. The opportunities for students to experience "doing science" directly are thus limited in this series.

The strengths of this program lie in the connections it makes. The sciences are shown to be intimately related to each other and to other forms of creative endeavor. As an overview of what science is, this package is unique. While students will not learn much specific science content from it, they will have the rare opportunity to see scientists and other intellectuals at work, see the excitement generated by the process, and get a broad idea of how and why scientists go about doing science.

Tailoring for Special Populations

Differentiation for high ability learners.

Because this program was not designed as a curriculum, it does not incorporate all of the elements of a standard program that were rated in the Phase III evaluation process used in this project; therefore Search for Solutions fails to achieve an average rating high enough for a classification of "recommended" for use with high ability learners in the Consumers' Guide. However, many of the unique features of the program make it an excellent supplemental program for high ability learners in middle or high school. The advanced reading level of Judson's book would be appropriate and challenging for these students. Because of its abstract way of organizing content and emphasis on themes, this program requires the use of higher order thinking skills and the ability to make connections within science and between disciplines. There is a quantum jump in the level of abstraction in this program relative to that of most science curricula. Open-ended problems are presented in Judson's book which concludes with eight problems that are in need of solution. These include questions about the origins of the solar system and life on earth.

The ideal situation for implementation of this program would be in a self-contained group of high ability learners. A seminar style approach would be appropriate with emphasis on reading, writing, discussions, and related scientific activities. In-depth research on the background for topics, historical events, and scientists that are featured in the films could be

done independently and shared with the group. The teacher could challenge students to pursue an advanced product in the form of an independent project. Investigative and experimental activities that tie in with the themes should also be incorporated.

Other special populations.

The Search for Solutions films portray a nice variety of role models who are female, black, or disabled. Included are: female scientists, a black doctor, a black psychologist, a blind scientist who studies seashells, a blind man who troubleshoots for a phone company, and a girl with an artificial arm. No other features are employed that are particularly advantageous to these populations of students.

CONCLUSION

Search for Solutions is not a typical science curriculum. Its emphasis is on illustrating scientific process rather than content. It would be an appropriate enrichment program for use by an experienced teacher with high ability and gifted students in upper middle grades or high school.

Curriculum Evaluation Form

Search for Solutions

Phase I Review

<u>Curriculum Design</u>	<table border="1" style="display: inline-table;"><tr><td>3</td><td>2</td><td>1</td></tr></table>	3	2	1	Average Rating
3	2	1			
Reviewer #1	2.06	2.13			
Reviewer #3	2.19	(Scale 1-3)			
<u>Classroom Design</u>	<table border="1" style="display: inline-table;"><tr><td>3</td><td>2</td><td>1</td></tr></table>	3	2	1	Average Rating
3	2	1			
Reviewer #1	1.99	1.98			
Reviewer #3	1.97	(Scale 1-3)			
<u>Technology</u>	<table border="1" style="display: inline-table;"><tr><td>3</td><td>2</td><td>1</td></tr></table>	3	2	1	Average Rating
3	2	1			
Reviewer #1	2.13	2.19			
Reviewer #3	2.25	(Scale 1-3)			

Phase II Review

<u>Science Content</u>	<table><tr><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr></table>	5	4	3	2	1	Average Rating
5	4	3	2	1			
Reviewer #1	4.25	3.75					
Reviewer #2	3.25	(Scale 1-5)					
<u>Science Process</u>	<table><tr><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr></table>	5	4	3	2	1	Average Rating
5	4	3	2	1			
Reviewer #1	3.07	2.93					
Reviewer #2	2.78	(Scale 1-5)					

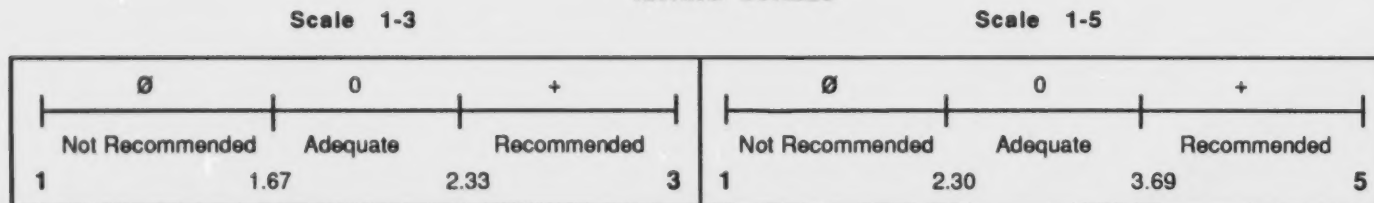
Phase III Review

<u>High Ability Learners</u>	<table><tr><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr></table>	5	4	3	2	1	Average Rating
5	4	3	2	1			
Reviewer #1	3.50	3.59					
Reviewer #3	3.67	(Scale 1-5)					

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Search for Solutions	2.13	1.98	2.19	3.75	2.93	3.59	A, B
	0	0	0	+	0	0	

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Grades 4-12+

Students and Research: Practical Strategies for Science Classrooms and Competitions

By J. H. Cothron, R. N. Giese, & R. J. Rezba

Kendall/Hunt, 1989

Dubuque, IA

OVERVIEW

Description

Students and Research is a teacher's manual for implementing independent student investigation and science research in classrooms. Part One of the four-part manual offers basic principles of experimental design with strategies for helping students plan experiments, generate ideas, construct tables and graphs, and write simple reports. Part Two presents advanced principles of experimental design including more sophisticated data analysis with descriptive and inferential statistics, complex experimental design, and formal written reports. The management strategies in Part Three encompass integrating research into the curriculum, working with parents, and a complete guide to assessing student research. The fourth part of the manual, "Strategies for Successful Science Competitions," includes guidelines for making effective oral presentations and displays, suggestions for preparing judges, and a review of major science competitions.

Published as a 230-page, 8 1/2 x 11 paperback book, Students and Research is illustrated with charts and samples of student work. Black-line duplicating masters included in each chapter serve as organizers for the various steps of the research process and guide students through practice activities.

Major Program Goals

The overall goal of Students and Research is to enable students to conduct independent investigation from simple to sophisticated levels and to share the results of their work. The authors are concerned that students experience "real science" that explores questions and problems rather than memorization of content.

Research Evidence of Effectiveness

R. N. Giese (personal communication, September 4, 1991) reports that the manual is an outgrowth of action research by the three authors. Each of the strategies was taught to teachers and students in Tidewater Virginia, the Greater Richmond Area, and in Hanover County, Virginia. Tests and student research products results were used as a formative evaluation for the redesign of the strategies and examples.

In 1989, drafts of chapters from Students and Research were used as the basis for two, three-hour courses involving 50 teachers, and the reactions of the teachers, their research projects and tests as well as the reactions of the teachers' students were used to make further revisions. The authors now have pre-post test data on over 540 middle-high school teachers that show the content of experimental design is effectively (i.e., statistically significant) taught to teachers via Students and Research and that there is subsequently a meaningful increase in the amount and quality of student research in the classrooms of teachers who have taken courses based on the book.

ANALYSIS

General Curricular Features

Curriculum design.

The authors maintain that the traditional "scientific method" describes the way experiments are reported not how they are generated. *Students and Research* presents step-by-step procedures for teaching students to generate and report scientific research. Students and their teachers must add the scientific content by determining appropriate topics and questions to research.

A distinctive feature of *Students and Research* is its attention to the total spectrum of experimental design principles. The basic and advanced research skills covered in the manual include:

Basic

- design experiments
- overcome design flaws
- write procedures
- construct tables and graphs
- generate ideas

Advanced

- use library resources
- design multi-variable experiments
- apply descriptive statistics
- establish statistical significance
- write formal papers

Classroom implementation.

For each step of the research process, *Students and Research* presents learning objectives for students and instructional strategies for teachers. The authors are careful to point out the complexity of the tasks expected of students, and they provide the structure and guidance necessary for success. For instance, the "four question strategy" for generating experimental ideas provides prompts for exploring the possibilities of a research topic. The questions include:

1. What materials are readily available for conducting experiments on (topic)?
2. How do (topic) act?
3. How can I change the set of (topic) materials to affect the action?
4. How can I measure or describe the response of (topic) to the change?

The manual then includes activities that provide practice and samples of blackline masters for recording student work.

The authors understand the constraints of classrooms and provide a section on management strategies for integrating research into the curriculum. They demonstrate how to modify

textbook "cookbook" activities to become components of experimental design and data analysis. They offer a teaching time line and the alternative of shorter, mini-projects rather than longer, independent research projects. Sample letters and permission forms are included that enlist parental support and spell out responsibilities and opportunities.

Two chapters provide methods for comprehensive assessment of student learning that accrues through independent investigation. First, a sample paper and pencil test assesses the mastery of concepts such as independent and dependent variables, graph construction and reading, and the quality of experimental design. Secondly, detailed rating sheets with space for self evaluation, a peer/family evaluation, and a teacher evaluation lists criteria and suggested point values for each of the eleven steps of the research process. In addition to providing students with feedback on each aspect of their effort, the evaluation mimics the peer review that the scientific community imposes upon its members, thus providing the final step in the research process. From beginning to end, Students and Research models the quality of design and execution that it recommends for students.

Technology.

Unfortunately, the program does not encourage students to use computer technology in the research process. There is no recommendation of computer statistical packages for analyzing data, spreadsheets or databases for managing data, or word processing and desk-top publishing programs to facilitate writing reports and creating displays.

Exemplary Science Features

Science content.

No specific scientific content is addressed in Students and Research. The manual teaches experimental design. Students learn the processes and terminology of scientific research.

Science process.

This useful and important manual teaches the nuts and bolts of how science is accomplished. It gives teachers detailed strategies for providing the full spectrum of scientific research experiences. An example of the manual's comprehensive scope is the attention paid to both quantitative and qualitative data collection techniques. Also, it includes opportunities for open-ended investigation, using community resources, and working with people practicing science.

Tailoring for Special Populations

Differentiation for high ability learners.

For gifted learners, Students and Research offers an independent study program that can be tailored to meet their specific needs. The program provides a scaffold so that gifted learners can assume responsibility for their own learning and monitor their work to create high quality, original products. Because students can choose the content and teachers can help determine appropriate complexity, students have open-ended opportunities for research.

Students and Research enables teachers of gifted learners to become facilitators and coaches.

With this manual, a teacher can work with a small group or with an individual to teach research skills and procedures. Students can then work independently and receive assistance when needed from the teacher.

Other special populations.

The occasional photographs in Students and Research show a diverse group of students and adults conducting research. Otherwise, the manual includes no special features that are particularly advantageous to girls, minorities, or disabled students.

CONCLUSION

Students and Research presents the continuum of research skills from basic to advanced, and it addresses each skill with detailed instructional strategies. Research is a complex process with some of the components often overlooked in busy classrooms. Students and Research offers an engaging, accessible program that ensures that each step receives specific attention.

Students and Research is particularly appropriate for gifted learners because of its open-ended, independent possibilities. By using the manual, students and teachers can negotiate a program tailored to individual interests and abilities.

Curriculum Evaluation Form

Students and Research

Phase I Review

Curriculum Design

3	2	1
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Average Rating

Reviewer #1

3.00

3.00
(Scale 1-3)

Classroom Design

3	2	1
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Average Rating

Reviewer #1

2.94

2.94
(Scale 1-3)

Technology

3	2	1
---	---	---

Average Rating

Reviewer #1

NA

NA

Phase II Review

Science Content

5	4	3	2	1
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Average Rating

Reviewer #1

4.60

4.80

Reviewer #2

5.00

(Scale 1-5)

Science Process

5	4	3	2	1
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Average Rating

Reviewer #1

4.66

4.58

Reviewer #2

4.50

(Scale 1-5)

Phase III Review

High Ability Learners

5	4	3	2	1
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Average Rating

Reviewer #1

4.27

4.64

Reviewer #3

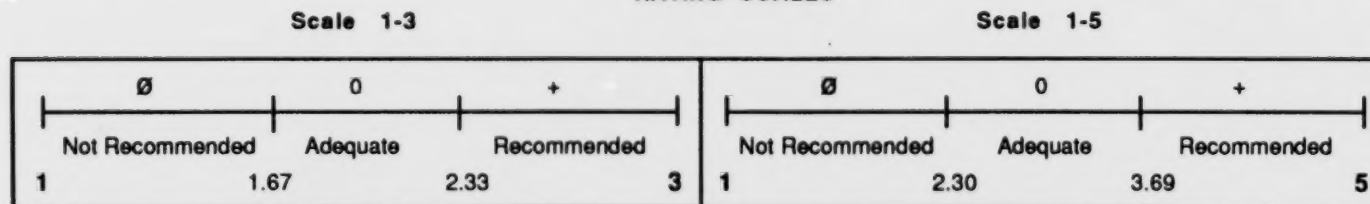
5.00

(Scale 1-5)

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Students & Research	3.00	2.94	NA	4.80	4.58	4.64	
	+	+		+	+	+	

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Teaching Integrated Mathematics and Science (TIMS)

Grades K-6

M/C 250

The University of Illinois at Chicago

Box 4348

Chicago, IL 60680

1992

OVERVIEW**Description**

The TIMS program has been in development since 1985. It is based on over 80 laboratory experiments that have been developed collaboratively by a physicist and a mathematician. The developers are presently working under a five-year NSF grant to develop a curriculum that will encompass an entire mathematics program and a major portion of the science program for grades K-6. Students will spend up to two weeks each month doing the experiments, which will be supplemented by math activities, a nonstandard mathematics textbook, and TIMS "adventure books" that relate math and science to history, technology, and real world applications. The project is also developing teacher's guides, transparencies, wall charts, and other teaching aids. The materials that were considered for purposes of this review were the laboratory experiments and the TIMS Tutors (pages of background information for teachers) that were available during the developmental stages of the program. The materials were in draft stage at the time of this review but should be published commercially by the fall of 1992.

Major Program Goals

The major goal of TIMS is the mastery of process skills through the carrying out of experiments.

Research Evidence of Effectiveness

The developers conducted research in Chicago schools during the 1986-1987 school year to evaluate the effectiveness of TIMS. A 22 question pre-test of mathematics and science process skills was administered in September, 1986 to approximately 5000 students in 13 schools in grades 1 to 8 followed by a post-test in May, 1987. The subjects represented a cross section of Chicago students in terms of race, SES status, and national academic test level. The major topics covered on the test were length, area, volume and mass, understanding and interpreting bar and point graphs, proportional reasoning and simple algebra. An average of 3.5 TIMS experiments were done per grade in each school with a range from 1.5 to 10. The study found an average net increase of two grade levels in test scores on the selected topics with even greater gains in the earlier grades. Researchers corrected for natural growth that would have occurred without any math/science instruction. Improvement was independent of income status or national academic test level. However, the study found that improvement was positively correlated with the number of TIMS experiments that were done during the school year. It also found that at least 4 experiments per year needed to be done to achieve a standard deviation of improvement. The one area that did not experience gains was in proportional reasoning. The researchers attribute this to very little teaching of proportions due to lack of confidence on the part of the teachers. (Goldberg and Wagreich, 1989).

ANALYSIS

General Curricular Features

Curriculum design.

The TIMS developers characterize their program with the words "variable" and "experiment." Variables were chosen as a focus because they are intrinsic to both mathematics and science. The marriage between the two is artfully demonstrated throughout these materials. Mathematics is employed as a language that one must speak to think scientifically. Not only does the program allow children to see the motivation for studying mathematics; but it also allows them to behave like scientists. The curriculum is composed entirely of experiments that are done by the students rather than by teacher demonstration. The following TIMS four-step process is used:

- 1) draw a picture of the experiment.
- 2) collect data and organize it into a data table.
- 3) make a graph of the data.
- 4) answer a series of rigorous comprehension questions.

Picture drawings provide a bridge between the concrete experience and the mathematical abstraction. The data collection and graphing require a good deal of precise quantitative work. Mathematical skills include: graphing (seen as a skill that is common to a large number of disciplines), computation, estimation, ratio and proportion, simple algebra, interpolation, and extrapolation. The comprehension questions include comparisons (such as "What was the percentage difference between your lung capacity and the average lung capacity?") and predictions (such as "What would you expect to happen if you doubled the mass of your object and then repeated the experiment?")

TIMS deemphasizes rote memorization of facts but instead emphasizes manipulation of data. Concepts are presented with some built-in options for tailoring the demands to the development of the students. For example, averages can be done using numerical calculations or by visually selecting the middle point of a set of data points on a graph. Within the Comprehension Questions section of each experiment, questions vary from concrete to abstract, thus allowing for accommodation of various abilities or skill levels of students. The program begins with the variables of length, area, volume, mass and time and progresses to the more complex variables of density, velocity, and acceleration. Each experiment can be used with a range of grade levels. No definitive sequencing is suggested.

Classroom implementation.

TIMS experiments do not constitute a full year science program. The program recommends spending eight to ten weeks on TIMS experiments. Each major section of TIMS experiments includes a TIMS Tutor that provides a lesson for teachers on the concept being developed (e.g., length, volume, velocity, inertia, proportional reasoning). The background information that is included with every TIMS experiment (called Teacher Lab Discussion) is thorough and complete, but TIMS might still be daunting to a teacher without adequate training and support. A major element in the TIMS program is its training program for teachers with ongoing support from a lead teacher in the school. In the Chicago-area program, at least two full days of staff

development were provided for teachers before they started the program, followed by monthly four-hour workshops and considerable in-classroom support during the year. The training component is essential to success with the program. The teacher of the TIMS program is not a lecturer but a facilitator and guide through the experimental process while students work in small group collaborative settings to carry out their experiments.

Formal assessment is not highlighted in the TIMS program. It is suggested that the first step of the process, drawing the picture, can be used as a check point. Observational assessment is encouraged. The comprehension questions should be monitored by the teacher. The 22-question test that was developed for use in the research on effectiveness of the program (or a similar test) could be used to test students at the beginning and end of each school year.

The TIMS program is lacking in bibliographic materials to be used as extensions for teachers and students. The experiments that were reviewed did not explicitly state objectives. Extension activities are not labeled but opportunities present themselves within the experiments. For example, in the "Arm Span Versus Height" experiment the Teacher Lab Discussion mentions that the resulting ratio of average height to average arm span should be the same for eighth graders as for the third graders who did the experiment but the cluster of data points would shift. The discussion mentions that this would be a nice addendum for third graders to investigate. In many experiments, a different manipulated variable could be chosen for further experimentation.

Technology.

No special technology features other than scientific materials such as magnets, batteries, and calculators are included in this curriculum.

Exemplary Science Features

Science content.

TIMS was designed to integrate the teaching of mathematics and science through the exploration of fundamental scientific variables. In the earliest grades, the emphasis is on the basic variables of length, area, volume, mass, and time. Later lessons introduce density, force, and acceleration. The overall emphasis is on physical science, and indeed, a number of basic physics concepts, such as work and friction, are developed in depth. TIMS thus does a good job of delivering fundamental physical science content. Although a few experiments using biological materials (those using photosynthesizing plants, growing fungi, and measuring human lung capacity) are present, the emphasis in each is on an underlying mathematical principle rather than on the biology of the system under study. Content is not a focus here. Rigorous, mathematically grounded experimentation is. Career education, moral and ethical aspects of science, and broad linkages to areas outside of science are not featured.

Science process.

TIMS has a uniform way of treating the experimental process. In each experiment, children follow the same four-step procedure. First, they draw and label a picture of the experiment. Second, they set up a data table for the two primary variables in the experiment; the manipulated variable and the responding variable. Next, they do the experiment and collect the data. The third experimental process step is the graphing of the data. Finally, the students

answer questions based on the experiment and on the graphed results. This is a good simplification of the scientific process: drawing and labeling the parts of the experimental step, making a data table in advance gets them organized to collect their data, and making and interpreting the graph forces them to think about the relationships between the variables they have tested. The experiments are preplanned; the students carry them out as instructed. The results are not always predictable in advance, so the experiments are somewhat open-ended. In addition, a number of the units have good extension possibilities for experiments that the students can plan and carry out on their own.

The strongest part of the curriculum is its attention to rigorous data analysis. Graphing is used as a sophisticated tool for data analysis and for prediction of the results of experiments that have not yet been performed. The properties of different kinds of curves are explored, curve-fitting techniques are introduced, the derivations of mathematical relationships between variables based on the graph are handled in explicit detail. This is a much more mathematically rigorous use of graphing than is found in any other curriculum package reviewed for this project.

Tailoring for Special Populations

Differentiation for high ability learners.

The TIMS curriculum holds great promise for high ability learners. It emphasizes higher level thinking skills with strong emphasis on both inductive and deductive reasoning. Within most experiments students not only draw conclusions based on their data, but also deduce answers to new questions based on earlier conclusions. Opportunities for using advanced mathematical skills are included. For example, after an experiment where students graph the relationship of perimeter to area of squares, they are asked to predict the perimeter versus area curve for a set of circles. The activities are structured in a way that allows high ability students to experience the lessons in a more abstract way, such as by making generalizations. Higher levels of data analysis can be required of the more mathematically adept students.

For high ability learners, the pacing of the experiments can be adjusted to an appropriate level. A self-contained group could progress more rapidly than others or perhaps complete more experiments. More opportunities to develop advanced products and to extend the content or skills need to be emphasized. In a heterogeneously grouped classroom, a teacher could individualize some of the experiments, by modifying the level of expectations within the experiments or allowing high ability students to work alone or in a small group to complete additional experiments.

Other special populations.

The TIMS approach may be helpful to students who have difficulty with English and/or reading. The drawing, labeling, and hands-on aspects are techniques that are frequently used by teachers who work with students who are not native speakers of English. The hands-on nature of the investigations may also be helpful to girls and minority students.

CONCLUSION

The TIMS curriculum is an innovative, non-traditional blend of science process skills and mathematics that uses primarily physical science content as a vehicle to achieve these skills. It is, by far, the most quantitatively oriented curriculum reviewed for this project. It could be described as a hands-on, thinking, problem solving curriculum. The final format of the materials is unknown to the reviewers as they were reviewed in draft stage. However, the materials show a great deal of potential for a flexible and challenging program. High ability learners and science-prone students can benefit from using it as part of a science program.

REFERENCES

- Goldberg, H., & Wagreich, P. (1989). Evaluation of a model integrated mathematics science program for the elementary school. International Journal of Educational Research, 14, (2), 193-214.
- Goldberg, H., & Wagreich, P. (1989). "Scientists in the Classroom." Unpublished article, University of Illinois at Chicago, TIMS project.

Curriculum Evaluation Form

Teaching Integrated Mathematics and Science (TIMS)

Phase I Review

<u>Curriculum Design</u>	3 2 1	Average Rating
Reviewer #1	2.77	2.83
Reviewer #2	2.89	(Scale 1-3)
<u>Classroom Design</u>	3 2 1	Average Rating
Reviewer #1	2.26	2.38
Reviewer #2	2.49	(Scale 1-3)
<u>Technology</u>	3 2 1	Average Rating
Reviewer #1	NA	NA
Reviewer #2	NA	

Phase II Review

<u>Science Content</u>	5 4 3 2 1	Average Rating
Reviewer #1	3.42	3.46
Reviewer #2	3.50	(Scale 1-5)
<u>Science Process</u>	5 4 3 2 1	Average Rating
Reviewer #1	3.71	3.71
Reviewer #2	3.71	(Scale 1-5)

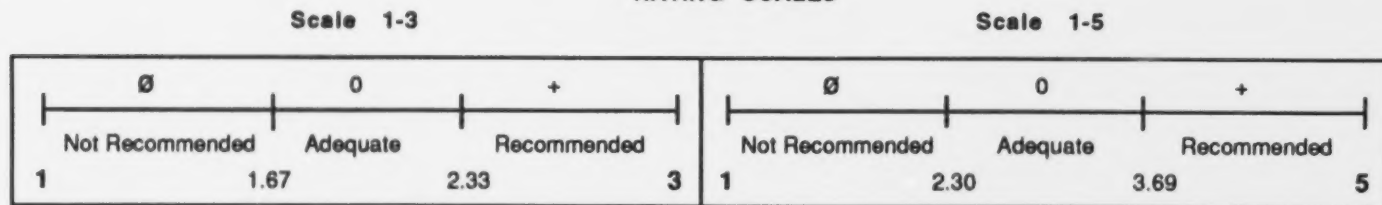
Phase III Review

<u>High Ability Learners</u>	5 4 3 2 1	Average Rating
Reviewer #1	3.92	3.71
Reviewer #3	3.50	(Scale 1-5)

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Teaching Integrated Mathematics and Science	2.83 +	2.38 +	NA	3.46 O	3.71 +	3.71 +	A, B

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

The Voyage of the Mimi

Grades 4-8

Bank Street College Project in Science and Math
 Distributed by Wings for Learning
 1600 Green Hills Road, P.O. Box 660002
 Scotts Valley, CA 95067
 1984

OVERVIEW

Description

The Voyage of the Mimi is an interdisciplinary curriculum that features a videotaped drama series about the seven member crew of the chartered boat Mimi and their whale research off the coast of New England. There are thirteen 15-minute episodes in the ongoing story of the Mimi and her crew. Following each episode there is a 15-minute "expedition" to a real place where similar science is conducted. Included are visits to the Smithsonian Museum of Natural History, a marine laboratory, an ocean water delineation operation on Long Island, a weather observatory on the top of Mount Washington, and nine other video field trips.

The video segments are available on video cassettes or video disks, which contain additional background information. A paperback book, called "The Book," supplements the films for students. It summarizes the drama series and expeditions and includes activities. The teacher's Overview Guide contains detailed suggestions about teaching the curriculum, blackline masters for enrichment activities, a navigation wall chart and a marine mammals wall chart. Four learning modules are sold separately: "Maps and Navigation," "Introduction to Computing," "Ecosystems," and "Whales and Their Environment." Each includes a teacher's guide, student book, and Apple II computer software. "Whales and Their Environment" comes with light, sound, and temperature sensors that connect to a computer, converting it into a science laboratory. A Language Arts Resource Guide and an Interdisciplinary Guide are also available. Wings for Learning publishes "The Mimi Experience" newsletter, which includes up-to-date science news and additional suggested activities. Other materials including a videodisc on whales, a computer database on whales, and software about tidepools can also be purchased.

Major Program Goals

No overall objectives are listed in the Overview Guide. Individual objectives are included for each episode and expedition.

Research Evidence of Effectiveness

No summative research evidence is available for the effectiveness of The Voyage of the Mimi. Rather, the developers conducted extensive formative research during the development stages of the program by field testing with teachers and students. Feedback from these trials was incorporated into the materials. Some specific pieces of the program have been studied further. For example, a study of students who used the Island Survivors software game from the Ecology module of the Mimi program showed evidence that some skills and concepts from the microworld environment of the software were transferred to new settings (Martin, Shirley, and McGinnis, 1987).

ANALYSIS

General Curricular Features

Curriculum design.

The video portions of The Voyage of the Mimi are the soul of the curriculum. They also serve as a springboard to exploration in other areas. The drama episodes are masterfully written, acted, and filmed. They are designed to captivate even the most reluctant students. The Voyage of the Mimi organizes its content around themes such as whales, oceans, and ecosystems. Scientific knowledge and examples of scientific process are woven into the plot. Interactions of crew members also have social and personal significance for viewers. For example, viewers see how Sally Ruth handles her deafness and how the other crew members react to her. Throughout the voyage there are moments giving examples of accomplishment, stress, disappointment, and decision-making.

The nonfiction expeditions which follow the drama episodes allow students to see scientists at work and are magnificent "field trips" to sites that would rarely be available to students. For example, in one of the expeditions Mark Graham, the actor who plays Arthur in the Mimi drama, visits a pair of scientists who for over 17 years have studied humpback whales and the sounds they make. In another episode Ben Affleck, who plays C.T., visits the U.S. Army Reserve Institute of Environmental Medicine where he experiences windchill effects in an Arctic Chamber.

An optional Interdisciplinary Guide provides suggestions for four units: whales, weather, communication, and survival. This guide, along with the Overview Guide, the student book, and the four learning modules provide follow-up activities, extension ideas and links to interdisciplinary activities.

Classroom implementation.

The Overview Guide does a good job of telling a teacher how to use the curriculum. There are excellent discussion questions for use before each video is shown and another set for post-viewing discussion. The questions allow for prediction, speculation, and divergent thinking. Materials contain a balance of teacher-directed, independent, whole class, and cooperative activities. The guide also contains many supportive materials. Blackline masters are included for use as worksheets. Background information for each lesson is provided for teachers along with an extensive resource section on whales in the Overview Guide.

The materials foster active engagement of higher level thinking skills. However, without the use of the learning modules and follow-up activities, the curriculum could be reduced to a passive video watching exercise. Potential exists for open inquiry extension and exciting interdisciplinary connections but it is up to the teacher to implement those portions of the materials that fully reinforce and extend the content.

Two of the learning modules are devoted to science. In one of these, "Ecosystems," students are asked to build and study an ecosystem in an aquarium and determine whether certain snails are right-shelled or left-shelled. The computer game "Island Survivors" is a great opportunity for learning about food chains and the delicate balance of nature. Through its connections to

sensors, the "Whales" module uses a computer as a sophisticated laboratory tool in carrying out many worthwhile manipulative experiments.

The interdisciplinary nature of the Mimi materials is a major attribute that should be exploited. The Interdisciplinary Guide encourages teachers to make up their own interdisciplinary units by creating curriculum webs, which are skillfully demonstrated in the guide. This guide and the Language Arts Guide have extensive resource lists and bibliographies of related literature. Suggested activities include researching red tide or edible plants, building a model boat, giving an oral explanation of knot tying, making films, keeping journals, making population estimates, keeping a file of newspaper articles on current science topics as a resource for writing fiction or writing about these topics, or learning the manual alphabet handsigns for the deaf. These can be used for all students or assigned as independent extension projects.

Unfortunately, assessment instruments are not included among the materials. It is suggested that students keep all their work in a folder for assessment purposes. Teachers are encouraged to circulate among groups to make observational assessments while students are working. Another suggestion, consistent with the interdisciplinary nature of the materials, is to have students write both before and after the video series about what scientists do.

Technology.

The science in this curriculum is well supported by innovative technology. The video component captures the interest of students, illustrates scientific process and takes students into the workplaces of real scientists in a much more effective way than a book can. The learning module, "Introduction to Computing," is available to develop computer literacy skills.

The sensors and software in "Whales and Their Environment" allow for a fast, accurate method of data collection, display, and comparison that dramatically illustrates the power of the computer as a tool in science. Some of the investigations such as measuring the amplitude of sound, would be very difficult, if not impossible, to carry out without sensors. However, there is also some benefit in having students organize, graph, and compare data by hand.

The "Island Survivors" game is a great example of a model ecosystem. As they play, students see an ecosystem in action along with the implications of changes that are made by humans in that ecosystem. The game can be played over and over, using different strategies. It can be played alone or in a small group.

Exemplary Science Features

Science content.

The scientific content of the Voyage of the Mimi is substantial. This curriculum covers important concepts in depth without watering down explanations or vocabulary. It covers advanced topics, such as wave behavior, in an intuitive, understandable way. Abstract scientific concepts are presented in dramatic situations in which their practical aspects are immediately apparent, creating a need for the student to understand their more abstract aspects. The interdisciplinary nature of the curriculum results in the integration of concepts from physics, biology, mathematics, and other disciplines in each segment of the Voyage.

Discussions on the tapes of current issues such as animal rights, the use of pesticides, and endangered species convey the moral and ethical aspects of science. In one particularly powerful segment, a physicist describes his decision to stop making bombs and do something more constructive--making drinking water from seawater. Examples such as these should prompt in-class discussions of the relationship of science to the real world.

Science process.

The Voyage of the Mimi, both through the tapes and through its other activities, conveys the feeling that science is an ongoing process. In the tapes, students see both dramatized and real scientists at work. The dramatic segments convey the "two steps forward, one step back" aspect of the scientific process. Scientists are shown in disagreement about their science and its implications and they even occasionally make mistakes. The interviews with real scientists do a first-rate job of career education as they convey the excitement of doing science. The combination of dramatic segments and real-life interviews will help to dismiss any "lab coat" stereotypes of scientists and the scientific process that might have been held previously by students.

The nature of the scientific process is best conveyed by the many laboratory and computer experiences available in the Voyage of the Mimi. The level of involvement of the students in these activities will be dependent on choices made by the teacher; failure to implement full use of the materials available will significantly weaken the impact of the program. Most of the activities and experiments are verification exercises rather than true experiments. They do, however, serve nicely to illustrate, clarify, and reinforce points made in the student guides and films. More open-ended exploration opportunities occur mainly in the suggested extension activities.

A particularly interesting aspect of the Voyage's activities is its focus on the scientific use of technological tools. Computer modeling of complex phenomena is an important tool for scientists. Students playing the "Island Survivors" computer game are, in reality, working with a mathematical model of an ecosystem, and have a rare opportunity to explore the usefulness of computer modeling. The computer is also used in Mimi to simulate navigational instruments and to take data through external probes during student laboratory experiences.

Tailoring for Special Populations

Differentiation for high ability learners.

The Voyage of the Mimi holds a good deal of promise for high ability learners. The integration of ideas, themes, and issues is exemplary. The connections between science, math, social studies, and language are expertly presented and seem very natural. The scientific content is significant and challenging. The vocabulary is high level and often incorporates the etymology of the words in the presentation. High level questioning and inquiry-based activities are included but need to be favored over some of the more routine questions and exercises in order to benefit high ability learners. A vast array of materials and ideas are contained in this curriculum. Still the teacher will make the difference in meeting the needs of high ability learners by making choices in implementing appropriate pieces of the curriculum.

Since there are so many activities that are done individually or in small groups, high ability students could be accommodated in a heterogeneous classroom by directing these students to the more challenging and open-ended activities. One example that is suggested is to have students simulate the activity of a paleontologist by reassembling the skeleton of a chicken. Another example would be to have students design their own field study or experiments with snails.

If high ability learners are in a self-contained group, the teacher can offer this curriculum as early as grade 4. The pace of the whole program could be adapted, probably through diagnostic pre-testing and compression of material, then by choosing activities and offering extensions based on students' interest and ability. Given the sophisticated equipment available in the "Whales" module, students could design some really marvelous experiments of their own, thus actually behaving like scientists.

Though the Mimi materials have no specific provision for bringing role models into the classroom, the real scientists who appear in the videos are quite impressive and are shown in their own scientific environments.

Other special populations.

This curriculum is well rounded in its inclusion of role models for girls, minorities, and disabled people. The seven member crew of the Mimi includes a female scientist, a black teenager, a Hispanic scientist and deaf female graduate student. Other female, minority, and disabled scientists appear in the video expeditions. Science is portrayed as a viable field and activity for everyone.

CONCLUSION

The Voyage of the Mimi is a high quality program that is not only rich in science content and process but is also highly interdisciplinary. It is a curriculum that should make any student like and learn science; but in particular it incorporates many features that make it commendable for high ability and gifted learners. However, since there is so much to choose from within the materials, the teacher of the gifted learner must be cautious to select a full set of activities that avoid routine exercises and that focus on open-ended, challenging extension activities. Plenty of these activities are available and even more suggest themselves.

ADDENDUM

The Second Voyage of the Mimi has a similar design and many of the attributes of the original curriculum. It features 12 video segments of a drama and 12 documentary expeditions.

In this drama, Captain Granville and C.T. charter the Mimi to two archaeologists who are studying the ancient civilization of the Maya who lived 1500 years ago on the Yucatan Peninsula of Mexico. Especially strong math, social studies, and science components are present in the Second Voyage but there are also elements of art, language arts, and foreign language. A comprehensive bibliography that is organized around interdisciplinary themes appears in the Overview Guide. The "Sun Lab" learning module studies day and night and the seasons. It uses a discovery approach and is supported by computer software.

The Second Voyage shows students that the science they saw practiced in the whale search in Mimi is characteristic of science in other places and with other subject matter. It holds the same promise for gifted students as the first voyage. And, once again, the new videos do a superb job of showing that science and math are exciting and open to everyone, regardless of gender, race, or disability.

Curriculum Evaluation Form

Voyage of the Mimi

Phase I Review

Curriculum Design

3	2	1
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Average Rating

Reviewer #1

2.87

2.83

Reviewer #3

2.78

(Scale 1-3)

Classroom Design

3	2	1
---	---	---

Average Rating

Reviewer #1

2.79

2.85

Reviewer #3

2.90

(Scale 1-3)

Technology

3	2	1
---	---	---

Average Rating

Reviewer #1

2.75

2.84

Reviewer #3

2.92

(Scale 1-3)

Phase II Review

Science Content

5	4	3	2	1
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Average Rating

Reviewer #1

4.91

4.96

Reviewer #2

5.00

(Scale 1-5)

Science Process

5	4	3	2	1
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Average Rating

Reviewer #1

3.93

4.04

Reviewer #2

4.14

(Scale 1-5)

Phase III Review

High Ability Learners

5	4	3	2	1
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Average Rating

Reviewer #1

4.08

4.31

Reviewer #3

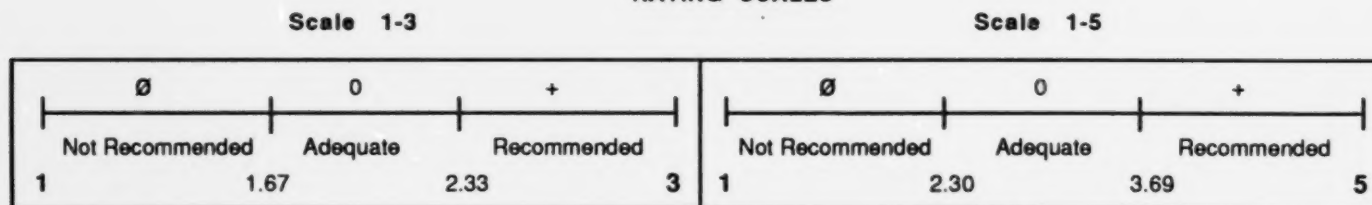
4.54

(Scale 1-5)

Consumer's Guide Rating Form

	Scale 1-3			Scale 1-5			
Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Voyage of the Mimi	2.83	2.85	2.84	4.96	4.04	4.31	A, B, C, D, E
	+	+	+	+	+	+	

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Appendix A:
Compilation
of
Curriculum Review Ratings

Consumer's Guide Overall Rating Form

Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
AIMS	<u>1.52</u> 3 #	<u>1.54</u> 3 #	NA	<u>1.65</u> 5 #	<u>1.72</u> 5 #	<u>1.42</u> 5 #	
Biological Science (BSCS)	<u>2.84</u> 3 +	<u>2.74</u> 3 +	Not Rated	<u>4.75</u> 5 +	<u>3.97</u> 5 +	<u>4.04</u> 5 +	A, B
Challenge of the Unknown	<u>2.62</u> 3 +	<u>2.51</u> 3 +	<u>2.69</u> 3 +	<u>3.88</u> 5 +	<u>3.93</u> 5 +	<u>4.16</u> 5 +	A
CEPUP	<u>2.93</u> 3 +	<u>2.49</u> 3 +	NA	<u>4.33</u> 5 +	<u>4.00</u> 5 +	<u>3.74</u> 5 +	A, B, C, D
Discover Science	<u>2.03</u> 3 0	<u>1.86</u> 3 0	NA	<u>2.78</u> 5 0	<u>1.46</u> 5 #	<u>1.83</u> 5 #	
ESS	<u>2.85</u> 3 +	<u>2.49</u> 3 +	NA	<u>3.82</u> 5 +	<u>3.97</u> 5 +	<u>3.96</u> 5 +	A, B
Focus on Science (Merrill)	<u>2.21</u> 3 0	<u>2.36</u> 3 +	NA	<u>4.46</u> 5 +	<u>2.00</u> 5 #	<u>3.21</u> 5 0	
FAST	<u>2.76</u> 3 +	<u>2.63</u> 3 +	NA	<u>3.25</u> 5 0	<u>3.93</u> 5 +	<u>3.46</u> 5 0	
FOSS	<u>2.80</u> 3 +	<u>2.90</u> 3 +	NA	<u>4.42</u> 5 +	<u>4.37</u> 5 +	<u>4.16</u> 5 +	A, B, C, E

Rating Scale: Not Recommended = #

Adequate = 0

Recommended = +

Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Consumer's Guide Overall Rating Form

Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
GEMS	<u>2.71</u> 3 +	<u>2.68</u> 3 +	NA	<u>4.16</u> 5 +	<u>3.82</u> 5 +	<u>3.79</u> 5 +	A, B
Insights	<u>2.96</u> 3 +	<u>3.00</u> 3 +	NA	<u>3.85</u> 5 +	<u>4.33</u> 5 +	<u>4.53</u> 5 +	A, B, C, D
LEGO Logo	<u>2.75</u> 3 +	<u>2.15</u> 3 0	<u>3.00</u> 3 +	<u>3.43</u> 5 0	<u>3.78</u> 5 +	<u>4.21</u> 5 +	A, B, C, D
Middle School Life Science	<u>2.85</u> 3 +	<u>2.70</u> 3 +	NA	<u>4.67</u> 5 +	<u>4.11</u> 5 +	<u>3.38</u> 5 0	
National Geographic Kidsnet	<u>2.73</u> 3 +	<u>2.55</u> 3 +	<u>2.68</u> 3 +	<u>4.66</u> 5 +	<u>4.50</u> 5 +	<u>3.04</u> 5 0	
Prentice-Hall Life/Phys./Earth	<u>2.35</u> 3 +	<u>2.23</u> 3 0	NA	<u>4.71</u> 5 +	<u>2.58</u> 5 0	<u>2.67</u> 5 0	
SAPA	<u>2.59</u> 3 +	<u>2.21</u> 3 0	NA	<u>2.38</u> 5 0	<u>3.36</u> 5 0	<u>3.01</u> 5 0	
Science for Life and Living	<u>2.57</u> 3 +	<u>2.64</u> 3 +	NA	<u>2.78</u> 5 0	<u>3.58</u> 5 0	<u>2.50</u> 5 0	
Science Horizons	<u>2.74</u> 3 +	<u>2.79</u> 3 +	NA	<u>3.50</u> 5 0	<u>2.93</u> 5 0	<u>3.58</u> 5 0	

Rating Scale: Not Recommended = 0

Adequate = 0

Recommended = +

Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Consumer's Guide Overall Rating Form

Title of Materials	Curriculum Design	Classroom Design	Technology	Exemplary Science Content	Exemplary Science Process	High Ability Learners	Notes
Science and Technology	<u>2.23</u> 3 0	<u>2.07</u> 3 0	NA	<u>4.29</u> 5 +	<u>2.77</u> 5 0	<u>2.80</u> 5 0	
Science & Tech. for Child. (STC)	<u>2.82</u> 3 +	<u>2.95</u> 3 +	NA	<u>3.84</u> 5 +	<u>3.86</u> 5 +	<u>4.13</u> 5 +	A, B
SCIIS	<u>3.00</u> 3 +	<u>2.76</u> 3 +	NA	<u>3.80</u> 5 +	<u>4.15</u> 5 +	<u>3.20</u> 5 0	
Search for Solutions	<u>2.13</u> 3 0	<u>1.98</u> 3 0	<u>2.19</u> 3 0	<u>3.75</u> 5 +	<u>2.93</u> 5 0	<u>3.59</u> 5 0	A, B
Silver Burdett & Ginn Elem. Science	<u>2.36</u> 3 +	<u>2.30</u> 3 0	NA	<u>3.50</u> 5 0	<u>2.46</u> 5 0	<u>1.90</u> 5 #	
Students & Research	<u>3.00</u> 3 +	<u>2.94</u> 3 +	NA	<u>4.80</u> 5 +	<u>4.58</u> 5 +	<u>4.64</u> 5 +	
TIMS	<u>2.83</u> 3 +	<u>2.38</u> 3 +	NA	<u>3.46</u> 5 0	<u>3.71</u> 5 +	<u>3.71</u> 5 +	A, B
Voyage of the Mimi	<u>2.83</u> 3 +	<u>2.85</u> 3 +	<u>2.84</u> 3 +	<u>4.96</u> 5 +	<u>4.04</u> 5 +	<u>4.31</u> 5 +	A, B, C, D, E
Windows on Science	<u>2.25</u> 3 0	<u>1.88</u> 3 0	<u>2.42</u> 3 +	<u>2.38</u> 5 0	<u>2.07</u> 5 #	<u>2.08</u> 5 #	

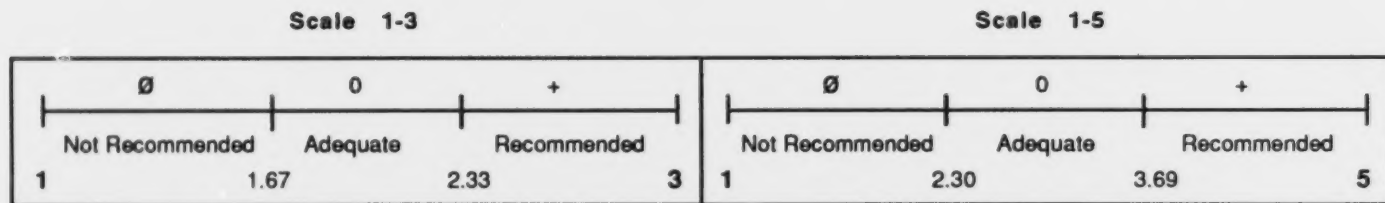
Rating Scale: Not Recommended = #

Adequate = 0

Recommended = +

Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

RATING SCALES



Notes: Appropriate for (A) Intellectually Gifted; (B) Science Prone; (C) Girls; (D) Minorities; (E) Disabled Students

Appendix B
The Curriculum Review Process
and
Criteria Rating Sheets

The Curriculum Review Process

Introduction

The curriculum review process evolved through several phases. It included a review of the literature calling for educational reforms in the 21st century, a search for materials, developing criteria, reading curricula, contacting publishers and developers for research evidence of effectiveness, numerous discussions among reviewers to reach consensus, and the writing of reviews. As a dynamic process, it changed and grew as each phase occurred and informed the other phases. Throughout the process, the definition and conception of an exemplary science curriculum for gifted learners expanded to accommodate the instructional needs of students, the information and technical needs of teachers, and the rigorous demands of true scientific literacy.

The Search for Materials

The curriculum review process started with the search for worthy curricula to review. Given earlier grants in science education, the Center for Gifted Education had ready access to several excellent materials. The science consultant team also was asked for specific curriculum, and they provided an overview of science curriculum that spanned projects from the 1960's to the curriculum projects that are currently under development.

The National Science Resources Center (NSRC), a curriculum resource center and information database established by the Smithsonian Institute and the National Academy of Sciences, served as a major source of information. Their publications, Science for Children: Resources for Teachers, and the NSRC Newsletter provided access to numerous curricula.

Letters soliciting curriculum for review were sent to all science curriculum publishers listed in NSRC's Science for Children: Resources for Teachers. Although not all publishers submitted their curricula, the resulting correspondence alerted project staff to new materials.

An ongoing, extensive literature search yielded additional sources and curricula. The ERIC CD-ROM database and professional science journals from the past two years were the major sources of information. Other major sources used to locate curricula are included in the reference section of this guide.

Selection of Materials to Review

The search for materials resulted in a bibliography that listed 62 curricula in the categories of basal text series, inquiry-based/hands-on materials, research-oriented materials, interdisciplinary and applied science materials, and curriculum resources. From this bibliography, a representative sample of curricula was selected for review. The rationale for selection included: breadth of use, reputation and/or evidence of appropriateness for high ability students, reputation as 'seminal' texts, and reputation as innovative or prototypical. After the initial review of 17 curricula, a new categorical system was developed that emphasized the primary focus of the reviewed materials. These categories were found to be: reading-based, inquiry-based, media-delivered, student research, interdisciplinary, science tools, and activity-based. This categorical system then guided the review of remaining curricula in the project.

Development of Criteria

Criteria for evaluating curriculum were developed by the project that provided a multifaceted lens for looking at various curricular components. Organized into three categories: (1) general curricular issues, (2) science content and process issues, and (3) features that tailor the curriculum for special populations, the criteria enabled

reviewers to focus on areas of concern and to identify specific strengths and weaknesses. Therefore, it was possible to find a curriculum strong in science content but weak in science process. Likewise, the curricular design of a set of materials might be deficient, but the activities within the materials could be recommended as useful resources. The comprehensive scope of the criteria forced reviewers to consider curriculum effectiveness from the instructional needs of teachers, the content and process demands of science, and characteristics of various groups of learners.

General Curriculum Features

The first group of criteria, general curriculum features, considered the construction of the curriculum. These criteria addressed design features, classroom design features, and technology. Here, the perspective of the teacher and instructional demands of the classroom were of primary concern. Each curriculum was evaluated for its overarching goals and how those goals were attained through the presentation of content. Then activities and materials were examined to determine how well they reflected the goals and content in addition to offering variety and being developmentally appropriate. Each curriculum was also evaluated for the presence and authenticity of multiple assessment procedures that measure outcomes as stated by program goals.

When the curriculum was based on technology such as interactive video or computers, a separate section of criteria looked at how successfully the technology was implemented. Here, the twofold purpose was to scrutinize what the technology offered that printed materials could not deliver and whether the use of technology fulfilled the demands of effective instruction.

Exemplary Science Features

This section of the criteria represented the specific elements of science curricula which are recommended in several new reports from science and mathematics foundations including Science for All Americans: Project 2061 (AAAS, 1987) and Science Learning Matters (NAEP, 1988). Those reports recommended that curricula integrate scientific thinking with scientific behaviors and attitudes, make inter- and intra-disciplinary connections, encourage active and real (not "cookbook") exploration, focus on learning key concepts instead of "covering the material," and demonstrate the connections between scientific discovery and moral and ethical decision-making.

The criteria ensured that curricula provide students with the opportunity to study areas of science where research is relatively new and as of yet still theoretically unformulated as in the current state of research on possible health hazards associated with nuclear power. From this kind of study students learn the essential ambiguity of science, the role of personal values in interpreting data and that the study of science does not result in absolute answers.

Tailoring for Special Populations

The criteria for differentiation for high ability learners were expanded from the "general curriculum features" section. Here, higher order thinking skills and scientific thinking skills, learning through discovery, and creation of real products were of primary concern. In addition to these skill-based goals, the curricula should also challenge talented students to develop a qualitatively different frame of reference. For example, students should come to realize that knowledge is constructed instead of prescribed and that specific criteria are used in each discipline to judge the relative worthiness of conflicting information.

In order to engage women and minorities in science, curriculum must be sensitive to their unique perspectives. For women, it means opportunities to "connect" information by representing it in a context which is personally relevant and to make associations among areas of study. Both the study of and direct access to appropriate role models is desirable. For minorities, this means conscious adaptation of content to represent the perspectives of the minority student and instructional adaptations to fit their learning styles. For disabled students this means

providing greater individualization and flexibility in how, where, and under what circumstances science may be learned. All special population groups also would benefit from the realization that science, far from being cold, impersonal and isolated, is intimately linked with the world of people.

The Review Process

Three reviewers with different expertise and perspectives evaluated each curriculum by using the criteria developed by the project. First, a materials specialist conducted a thorough review of the entire curriculum by applying all three sections of criteria (Phase I, II, and III). The general curriculum features were rated on a scale of 1-3. The sections that address exemplary science features and tailoring for special populations were rated on a scale of 1-5. In addition, specific examples of how the curriculum met or failed to meet certain criteria were noted during this part of the review.

Secondly, an expert in gifted education and curriculum development rated each curriculum by completing the "general curriculum features" section (Phase I) and the "differentiation for gifted learners" section (Phase III) of the criterial checklists. Likewise, a scientist rated the curriculum by completing the "exemplary science features" (Phase II) and "curriculum responsiveness to girls, minority concerns, and disabled" section (Phase III) of the criterial checklists. For curricula spanning the elementary grades, these two specialists critiqued grades two and six. In the cases of secondary curricula and resource materials, they critiqued the entire program. Both specialists made comments about particularly salient strengths and weaknesses of the curriculum as they conducted their reviews.

Using the comments and ratings from the gifted education expert and the scientist, the materials specialist then wrote a narrative review. Comments about the narrative were solicited from project staff, and the narrative was then revised. In this manner, a holistic review emerged based on criterial checklists as well as the responses of experts representing at least three different perspectives.

Finally, a rating scale was formulated to highlight strengths and weaknesses in the three phases of each curriculum. The scores each reviewer marked on the criterial checklists were averaged to obtain that reviewer's rating in the areas of curriculum design, classroom design, technology, science content, science process, and high ability learners. When a curriculum was particularly appropriate for the intellectually gifted, science-prone, girls, minorities, or disabled students, that strength was also noted on the rating scale. Then the scores of the three reviewers were averaged and the resulting scores were used to assess the curriculum as "recommended," "adequate," or "not recommended" in each of the rated areas.

The Narrative Review

The narrative review, the final piece of the review process, includes three sections: an overview, an analysis, and a conclusion.

The Overview

The overview orients the reader to the scope and presentation of the curriculum. This section contains a description of the materials, a listing of the major program goals, and a summary of the research evidence of the effectiveness of the program.

The major goals and objectives of a curriculum reflect the substance of the program and provide a glimpse of the program developers' vision. The goals listed in this part of the review are taken directly from the curriculum materials. Some curricula contain no statement of major goals or objectives, and this fact is reported in the

review. The omission of major goals, of course, precludes an overall research assessment of the effectiveness of the program.

The report of research evidence of effectiveness of a program informs readers if the program was field tested, followed up with summative research, or simply the result of commercial market research. In seeking research evidence for the reviews, ERIC data bases were searched for pertinent research reports. In addition, written requests for research evidence were sent to the publishers or producers of the curricula under review. For the purpose of these reviews, primarily research effectiveness of student learning, not teacher or student perception, is considered valuable.

The Analysis

The analysis of the curriculum which flows directly from the Phase I-III rating criteria contains three sections: (1) General Curricular Features, (2) Exemplary Science Features, and (3) Tailoring for Special Populations. The first section, General Curricular Features, considers curriculum design, classroom implementation, and technology aspects. Then, Exemplary Science Features, evaluates how well the curriculum meets the criteria for exemplary science content and science process. Finally, the analysis discusses how the curriculum accommodates or could be adapted to meet the unique needs of high ability learners, girls, minority students, and disabled students. The analysis offers educators consistent, comprehensive standards by which to compare one curriculum to another.

The Conclusion

The conclusion of the review summarizes the major strengths and weaknesses of the curriculum. It synthesizes information gleaned from the statement of major goals, the research evidence of effectiveness, and the analysis of how well the curriculum meets established criteria.

Summary

The review process offered an opportunity to view and review curriculum from the perspectives of various professionals and instructional demands. The criterial checklists served as the cornerstone of the review process, and provided the lens for the objective look at each curriculum. The rating scale then summarized the results of the checklists and gave consumers an opportunity to compare one curriculum with another. The narrative, the final piece of the review process, summarized the objective examination of each curriculum, including the more subjective reactions of the three reviewers, and offered suggestions and caveats for using the curricula in classrooms.

General Curriculum Features Evaluation Form

(Phase I Review)

Name of Reviewer: _____

Title: _____

Title of Curriculum to be Reviewed: _____

Appropriate Grade Level(s): _____ Original Copyright Date: _____ Date(s) of Revision: _____

Directions: Carefully read through all curriculum materials and then rate the curriculum by each of the following criteria on a scale of 3 = To a great extent; 2 = Adequate; and 1 = Not at all:

Curriculum Design

	3	2	1
1. <u>Rationale and Purpose</u>	3	2	1
--substantive and worthy?	3	2	1
--clear and understandable?	3	2	1
--logical order and integrated structure to scope and sequence?	3	2	1
--identified outcomes consonant with purpose?	3	2	1
2. <u>Curriculum Content</u>	3	2	1
--significant scientific concepts?	3	2	1
--significant information to explore concepts in depth?	3	2	1
--topics support concepts?	3	2	1
--engaging style of presenting information?	3	2	1
--topics and activities have personal meaning and social relevance for students?	3	2	1
--allowance for curricular differentiation for gifted learners?	3	2	1
3. <u>Curriculum Responsiveness to Developmental Needs</u>	3	2	1
--sequential exposure to scientific concepts from the concrete to the abstract?	3	2	1
--manipulative science materials used to support the curriculum?	3	2	1
--high active to passive activity ratio?	3	2	1
--sequential use of visual materials from the picto-centric to the text-centered?	3	2	1
--materials challenge students' current explanations and allow time for them to reconstruct their understanding of scientific phenomena?	3	2	1

Classroom Design

	3	2	1
4. <u>Instructional Objectives</u>	3	2	1
--clear and understandable?	3	2	1
--measurable?	3	2	1
--related to overall rationale and purpose?	3	2	1
5. <u>Activities</u>	3	2	1
--appropriate balance of teacher direction/student direction?	3	2	1
--developmentally appropriate activities?	3	2	1
--activities used to introduce topic (get students to explore topic to be studied)?	3	2	1
--activities clarify, reinforce and extend content?	3	2	1
--science integrated with other subjects, specifically language arts and mathematics?	3	2	1
6. <u>Instructional Strategies</u>	3	2	1
--are strategies varied?	3	2	1
--opportunities for problem finding and solving?	3	2	1

	--opportunities for open inquiry?	3	2	1
	--varied grouping approach, e.g., including opportunities for small group work?	3	2	1
	--cooperative work focuses on real problems with problem resolution rather than problem solution as goal?	3	2	1
	--opportunities to practice decision making strategies?	3	2	1
	--use of various types of questions (e.g., convergent, divergent, evaluative)?	3	2	1
7.	<u>Assessment Procedures</u>	3	2	1
	--presence of pre-post assessment measures?	3	2	1
	--use of observational evaluation?	3	2	1
	--use of authentic assessment?	3	2	1
	--objective attainment assessment measures?	3	2	1
	--assessment based on ability to get and to use information?	3	2	1
	--assessment based on outcomes of significance?	3	2	1
	--opportunity for overall evaluation?	3	2	1
8.	<u>Materials/Resources</u>	3	2	1
	--instructional materials begin with students' current knowledge?	3	2	1
	--supportive bibliography for teachers?	3	2	1
	--frequent student misconceptions are identified for teachers?	3	2	1
	--bibliography for student extension reading?	3	2	1
	--supportive handout materials (informational, worksheets, etc.)?	3	2	1
9.	<u>Extension Ideas</u>	3	2	1
	--worthwhile, related activities for students to pursue independently?	3	2	1
	<u>Technology Features</u>	3	2	1
10.	<u>General</u>	3	2	1
	--actively engages students in higher order thinking skills and activities?	3	2	1
	--enhances and complements instruction?	3	2	1
	--provides effective interaction?	3	2	1
	--allows exploration otherwise prohibited by time, danger, or money?	3	2	1
	--provides simulations of models or experiments that cannot be experienced with real materials?	3	2	1
	--contains several levels of difficulty?	3	2	1
	--provides useful, corrective feedback?	3	2	1
	--easy to use?	3	2	1
11.	<u>Technical</u>	3	2	1
	--uncluttered screen design?	3	2	1
	--lucid, economical text?	3	2	1
	--dynamic visuals for abstract concepts?	3	2	1
	--useful help screens?	3	2	1
	--effective self-pacing devices?	3	2	1
	--comprehensive teacher manual that includes instructions for use and modification, inventory, and specifications?	3	2	1

Exemplary Science Features Evaluation Form
(Phase II Review)

Name of Reviewer: _____

Title: _____

Title of Curriculum to be Reviewed: _____

Appropriate Grade Level(s): _____

Directions: Carefully re-read through all curriculum materials and then, rate the curriculum by each of the following criteria on a scale of 5 = To an Exemplary Extent; 4 = To a Good Extent; 3 = Adequate; 2 = To a Limited Extent; and 1 = Not at All.

Science Content

	5	4	3	2	1
1. --content base in key areas of science that provide the fundamentals of basic science?	5	4	3	2	1
2. --content base in key areas of technology?	5	4	3	2	1
3. --inclusion of current science/technology content?	5	4	3	2	1
4. --inclusion of historical and current science/ technology issues?	5	4	3	2	1
5. --topics linked to broad scientific concepts (intradisciplinary connections)?	5	4	3	2	1
6. --topics linked to ideas outside of science (interdisciplinary connections)?	5	4	3	2	1
7. --balance of qualitative and quantitative information?	5	4	3	2	1
8. --balance of theoretical and practical science?	5	4	3	2	1
9. --presence of moral and ethical dimensions of science and technology?	5	4	3	2	1
10. --global perspectives on relationship of science and technology to society and to developing nations?	5	4	3	2	1
11. --science is accurate and presented understandably?	5	4	3	2	1
12. --important science concepts are covered in depth?	5	4	3	2	1

Science Process

	5	4	3	2	1
13. --provision for the use of technology (e.g., computers, CD-ROM) as it can be applied to science?	5	4	3	2	1
14. --opportunities for open-ended scientific investigation (not simply verification exercises)?	5	4	3	2	1
15. --use of community resources?	5	4	3	2	1
16. --laboratory and field-work integral to and integrated with the curriculum?	5	4	3	2	1
17. --opportunities for students to have personal interaction with people practicing science?	5	4	3	2	1
18. --concern for career awareness?	5	4	3	2	1
19. --opportunities for students to work together to investigate a scientific/ technological problem?	5	4	3	2	1
20. --opportunities for students to work with a mentor to investigate a scientific/ technological problem?	5	4	3	2	1
21. --use of various questioning strategies integrated throughout the curriculum?	5	4	3	2	1
22. --active student involvement required by curriculum?	5	4	3	2	1
23. --scientific process demonstrated as approximation versus absolute rigidity?	5	4	3	2	1
24. --students are taught to build and test hypotheses?	5	4	3	2	1
25. --allowance for questioning of assumptions and diverse opinions?	5	4	3	2	1
26. --examples of unsuccessful science so that science-as-a-process is demonstrated?	5	4	3	2	1

Tailoring for Special Populations Evaluation Form
(Phase III Review)

Name of Reviewer: _____

Title: _____

Title of Curriculum to be Reviewed: _____

Appropriate Grade Level(s): _____

Although curriculum may be found exemplary from a technical and even subject area perspective, it is important to consider the extent to which curriculum can be tailored to the needs of more targeted groups of learners with special needs. Thus the Level III review process looks more closely at the features of exemplary curriculum for special populations.

Directions: Carefully re-read through all curriculum materials and then, rate the curriculum by each of the following criteria on a scale of 5 = To an Exemplary Extent; 4 = To a Good Extent; 3 = Adequate; 2 = To a Limited Extent; and 1 = Not at All.

Differentiation for High Ability Learners

		5	4	3	2	1
1.	--provisions for acceleration and compression of content?	5	4	3	2	1
2.	--use of higher order thinking skills (e.g., analysis, synthesis, evaluation)?	5	4	3	2	1
3.	--integration of content by key ideas, issues, and themes?	5	4	3	2	1
4.	--connection of scientific ideas to other disciplines?	5	4	3	2	1
5.	--opportunities for both inductive and deductive reasoning?	5	4	3	2	1
6.	--use of multiple teaching resources?	5	4	3	2	1
7.	--use of diagnostic-prescriptive teaching?	5	4	3	2	1
8.	--attention to instructional pacing?	5	4	3	2	1
9.	--advanced reading level?	5	4	3	2	1
10.	--opportunities for students to develop advanced products?	5	4	3	2	1
11.	--opportunities for independent learning based on student capacity and interest?	5	4	3	2	1
12.	--use of inquiry-based instructional techniques?	5	4	3	2	1

A. Curriculum Responsiveness to the Intellectually Gifted

- sufficiently advanced in content?
- sufficiently challenging?
- complex applications of concepts?
- product demands appropriately designed?

B. Curriculum Responsiveness to the Science Prone

- opportunities for extended and independent learning?
- opportunities for open-ended exploration?
- opportunities for in-depth work on selected topics?

C. **Curriculum Responsiveness to Girls**

5	4	3	2	1
---	---	---	---	---

- presence of information about contribution of women to science?
- opportunities to read about women in science?
- information provided about career opportunities for women?
- avoidance of bias and sex stereotyping in resource materials?
- use of varied teaching strategies, including hands-on, discussion, and cooperative learning?
- use of conceptual organizers for teaching new material?

D. **Curriculum Responsiveness to Minority Concerns**

5	4	3	2	1
---	---	---	---	---

- incorporation of effective social experiences?
- promotion of tolerance of self and others?
- global perspective with attention to non-Western cultures?
- emphasis on cultural similarities and differences?
- emphasis on analogical reasoning and associative thinking?
- presence of information about contribution of minorities to science?
- opportunities to read about minorities in science?
- information provided about career opportunities for minorities?
- avoidance of bias and ethnic stereotyping in resource materials?

E. **Curriculum Responsiveness to Disabled Students**

5	4	3	2	1
---	---	---	---	---

- options for individualized programming?
- data-based instructional decision-making?
- opportunities for variety of response modes?
- on-going collaborative planning for present and future environments?
- provision of tools for compensation?
- preparation for career/vocational and independent living skills?
- use of varied formats for guided and independent practice?

Appendix C:
Bibliography
of
Science Curriculum Materials

A. Basal Text Series**Grade Levels**

Addison-Wesley Science. (1992). Second edition. Menlo Park, CA: Addison-Wesley.

K - 6

This reading-based series is organized around the four strands of life science, physical science, earth science, and health science. At each grade level the four strands are subdivided into science themes: life science includes plants, animals, and ecology; physical science includes matter, energy, and technology; earth science includes the earth, weather, and space; health science includes human body and well being. Special features of the units include pages devoted to "technology today" and scientific careers.

Discover Science (1989). Glenview, IL: Scott, Foresman.

K - 6

This textbook series for grades K-6 is divided into four units at each level: Life Science, Physical Science, Earth Science, and the Human Body. Each unit, with the exception of the Human Body, is then grouped into content strands: plants, animals, and ecology make up the Life Science Units; matter and energy are included in the Physical Science units; earth, weather, and space comprise the Earth Science units. The teacher's manual suggests using a three step lesson plan: motivation, teaching, and assessment. Suggestions are given for activities for high ability learners, those in the mainstream, and for cooperative learning. In addition, the teacher's manual includes demonstration activities, discussion questions for students, and background information. This text centered curriculum represents what is widely used in the nation's classrooms.

Focus on Science. Columbus, OH: Merrill Publishing Company Focus on Earth Science (1989); Focus on Physical Science (1989); Focus on Life Science (1989); Biology: Living Systems (1989).

6 - 8

Each text in this series broadly covers the major topics in their respective fields. The main content is presented in the student and teacher's editions of the texts. Laboratory manuals for the teacher and student offer additional experiments. The Teacher Resource Package includes objectives charts, worksheets, teaching masters, tests, and enrichment masters.

Interaction Series. Chicago: Rand McNally & Company.

7 - 9

Interaction of Matter and Energy (1973).

Interaction of Earth and Time (1972).

Interaction of Man and the Biosphere (1970).

This textbook series, designed for junior high students, emphasizes a hands-on approach to learning and understanding science. The texts are structured in such a way that the subject content merely offers background information for the following scientific investigations. The investigations are structured "so that the teacher may guide students toward achieving maximum understanding through independent discovery." The students study fewer topics than with traditional science curriculum, but in much more detail.

Grade Levels

Middle School Life Science. (1991). Dubuque, IA: Kendall/Hunt Publishing Company

7 - 8

Middle School Life Science was developed by the Jefferson County, CO schools as the life science curriculum for their seventh graders. It covers ecology and human biology in depth, relating these topics to the personal lives of middle school students. The program includes many hands-on activities.

Modern Science Series. NY: Holt, Rinehart & Winston. Modern Earth Science (1989); Modern Life Science (1986); Physical Science (1986); Modern Biology (1989); Modern Physics (1984); and Modern Chemistry (1986).

7 - 12

The layout of the texts in this textbook series follows a familiar pattern. Each chapter begins with objectives, ends with review questions and/or problems, offers basic and indepth questions and/or problems, and includes an experiment of "Skill Building" activity. The investigations/experiments are not open-ended nor inquiry-based. Each of the texts give examples of careers in science, technological advances, and impacts of science on daily life. The Modern Physics and Modern Chemistry books claim to contain more material than normal first-year texts so that the teacher has more flexibility and can teach students of all ability levels. These two texts give the teacher a choice in what type of experiments they wish to undertake. Holt offers a choice of laboratory manuals to supplement the Chemistry and Physics texts--one having a more traditional approach and the other having an open-ended approach.

Prentice-Hall Science Series. Englewood Cliffs, NJ: Prentice-Hall.
Prentice-Hall Earth Science, (1988).
Prentice-Hall Life Science, (1988).
Prentice-Hall Physical Science (1988).

7-9

Each of the texts is divided into units which can be taught separately and in any order with the exception of the first chapter of each text. It introduces the scientific method, measurement, and tools used in each discipline. The basic content is covered in the Student Textbook for which there is a corresponding Teacher's Edition. There are laboratory activities at the end of each chapter of the texts, as well as in a supplementary laboratory manual. This series emphasizes "concepts, skill development and everyday life application" of science.

Grade Levels

Science and Technology. (1985). San Diego, CA: Coronado Publishers (now distributed by Harcourt Brace Jovanovich, Orlando, FL).

K - 6

Based on the broad themes of life, matter, and energy, Science and Technology looks at patterns and their relationship as a key element in the search for meaning. In the primary grades, students observe and experiment with objects and events in their immediate environment; then during the intermediate years study a planet or a station in space as it forms a support system for life. This curriculum considers science and technology to interact, one catalyzing the other.

Science Horizons (1991). Needham, MA: Silver, Burdett & Ginn.

K - 6

Problem solving and skill development are emphasized in this basal text series. Students in grades K-6 study four areas of science: life science, physical science, earth science and the human body. Types of activities include motivational, problem solving, skill development and cooperative learning activities. The teacher's edition offers suggestions for interdisciplinary lessons, especially using literature to stimulate students' interest in science. This text supports inquiry-based learning and allows for a hands-on approach.

Silver Burdett & Ginn Elementary Science (1989). Needham Heights, MA: Silver Burdett & Ginn.

7 - 12

The four strands of life science, physical science, earth science, and the human body are developed from kindergarten to grade six within this curriculum. A teacher resource file is available that includes copy masters for each chapter of the textbook, test copy masters, a Science Olympics activities booklet designed to challenge academically talented students, Invention Convention information, bulletin board posters, health copy masters, parent's letters in Spanish, a teacher edition of the workbook, color overhead transparencies, and a guide for helping students to achieve English proficiency. Although the program is sensitive to the goals of scientific process and inquiry, it is a textbook centered program.

Windows on Science. Warren, NJ: Optical Data Corporation.

K - 9

An interactive, videodisc-based curriculum, Windows on Science offers "Primary Science" for kindergarten through third grade; and then "Earth Science," "Life Science," and "Physical Science" for upper elementary and middle school. In addition to videodiscs, the program includes lesson plans, hands-on activities, and reading and writing components. This news-making program has been adopted as a textbook choice in Texas.

B. Inquiry-Based/Hands-On Materials

Grade Levels

Activities to Integrate Mathematics and Science (AIMS). Fresno, CA: AIMS Education Foundation.

K - 9

Developed as a supplementary, hands-on, integrated mathematics/ science program for kindergarten through ninth grade, the units in this program are published as individual booklets that span various grade levels. Each booklet contains ten to twenty investigations with a specific lesson plan, background information, procedures, discussion questions, and extensions. A sample of the twenty-six booklet titles includes: "Primarily Plants" and "Primarily Physics" for kindergarten through grade three; "Water Precious Water" and "Critters" for kindergarten through grade six; "The Sky's the Limit" and "Our Wonderful World" for grade five through nine. According to the developers, three major publishers are preparing correlations of AIMS to accompany their new science series.

Biological Sciences Curriculum Study (BSCS Blue Version). American Institute of Biological Sciences.

7-12

With the stated function of improving the education of the general population as well as students in school, BSCS prepares students to use scientific information and techniques in order to become competent decision makers. The several versions of the program, each of which incorporates a laboratory block in the program, provides options for both curriculum and approach. Although designed as a high school curriculum, BSCS is frequently used with middle school gifted students.

Challenge of the Unknown(1986). Seven-part film series produced by J.J. Crimmins, NY; Teacher's manual published by W.W. Norton, NY.

5 - 8

(Challenge of the Unknown is available to schools on free-loan video-cassettes, with permission to copy and keep the copied sets, a free teaching guide is included. For this service, contact Karol Media, Wilkes-Barre, PA).

Challenge of the Unknown seeks to enable students to use math as a problem-solving tool in the real world. The seven segments of the series which include **problem creation** as well as **problem solving** include "Situation," "Information," "Restatement," "Outcomes," "Management," "Estimation," and "Argument." Although math applications receive primary emphasis, the materials demonstrate scientific inquiry in action.

Grade Levels**Chemical Education for Public Understanding Program (CEPUP)(1990).**

7 - 9

Berkeley, CA: Lawrence Hall of Science, University of California.
Distributed by Addison-Wesley.

The CEPUP materials integrate chemical concepts and processes with societal issues through inquiry-based activities that emphasize problem solving and decision making. As of April 1991, eight modules comprise the program covering such topics as a chemical survey, solutions and pollution, threshold limits, risk comparison, groundwater, toxic wastes, plastics, and chemicals in food. The CEPUP manual and kit are designed for nonlaboratory settings. In this program, students collect and process scientific evidence and use it to make decisions about chemicals in the context of society.

Chemicals, Health, Environment, and Me (The CHEM Project). Berkeley, CA:
Lawrence Hall of Science, University of California.

5 - 6

CHEM is a series of ten units designed to help students understand the nature of chemicals and chemical interaction with the environment, how to collect, process, and analyze information, how to use scientific evidence for decision making, and how studying science and mathematics can be a part of their lives.

Developmental Approaches in Science and Health (DASH) (in development).

K - 6

Honolulu, HI: University of Hawaii. Curriculum Research and Development Group.

DASH is a hands-on, sequential K-6 program that integrates the content of science, health, and technology. DASH requires participation in staff development of all users of the program. Draft versions of DASH grades K-2 are completed; DASH activities for grades 3-4 are currently being pilot tested; grades 5-6 activities are in design stages. Publication of DASH is projected for 1994.

Delta Science Modules. Hudson, NH: Delta Education.

K - 6

Delta Education provides forty modules in the areas of physical science, life science, and earth science. Teacher's manuals along with comprehensive equipment and supply kits provide self-contained units for hands-on science instruction. The modular format allows for developing scope and sequence to meet various district needs.

Grade Levels

- DeVito, A., & Krockover, G. (1976). Creative Sciencing, a Practical Approach. Boston: Little, Brown & Co. 5 - 6

This book was written to provide a practical approach in the teaching of science to children in kindergarten through grade nine. It may be used along or with the accompanying book, Creative Sciencing: Ideas and Activities for Teachers and Children. The authors first set the stage for creative-science instruction, and then explore alternate strategies. The development of interest centers, assessment techniques, and an integrated approach to learning are all discussed. Instructors are encouraged to reproduce for their class specific exercises bearing a copyright notice included in the book.

- Elementary Science Study (ESS) (1966-1986). Newton, MA: Education Development Center. 5 - 8

Originally funded by the National Science Foundation and published by McGraw-Hill, some ESS units are currently out of print and are available from ERIC, other revised editions are available from Delta Education. The fifty-six hands-on units for kindergarten through grade eight allow children to experiment, to define their own questions, and to set their own goals. Some of the titles include: Behavior of Mealworms, Batteries and Bulbs, Changes, Crayfish, Kitchen Physics, Mapping, Mirror Cards, Pendulums, Senior Balancing, and Water Flow.

- Foundational Approaches in Science Teaching (FAST). Honolulu, HI: University of Hawaii, Curriculum Research and Development Group. 7 - 12

FAST is an interdisciplinary, environmental science program which emphasizes foundational concepts and methods of the physical, biological, and earth science and relates them to practical issues of human use of environments. The FAST curriculum is supported by empirical evaluation data. As a National Diffusion Network Developer/Demonstration Project, FAST materials are available only upon completion of a Teacher Training Institute.

- Full Option Science System (FOSS) (1989-1991 under development). Berkeley CA; Lawrence Hall of Science. 5 - 6

FOSS is a hands-on science program for grades three-four and five-six organized under the four topic strands of scientific reasoning and technology, physical science, earth science, and life science. For each strand, there are two activity modules. Each activity module includes content background information, ideas for preparing and managing the activities, detailed lesson plans, discussion questions, and interdisciplinary extensions. Conceptual themes such as systems and interaction, patterns of change, evolution, and models are integrated into the content strands.

Grade Levels

Great Explorations in Math & Science (GEMS). Berkeley, CA: Lawrence Hall of Science, University of California.

K - 10

GEMS publications include teacher's guides, assemble presenter's guides, and exhibit guides. The publications integrate math with life, earth, and physical science, using a "guided discovery" approach to learning. The teacher's guides, which include student materials, encompass two to fifteen class sessions which can be integrated into a curriculum or stand alone.

The Greenhouse Effect: An Investigation. Norfolk, VA: WHRO.

This videodisc includes approximately 27 minutes of video, 600 still frames of experiments, sources of greenhouse gases, history of buildup of greenhouse gases, projections into the future, and other related information. The Greenhouse Effect is an example of a locally-produced curriculum that combines interactive computer instruction with inquiry-based learning.

Improving Urban Middle School Science: A Collaborative Approach (in development). Newton, MA: Education Development Center.

7 - 8

This project is in the early stages of development. The curriculum will consist of eight thematic, science modules that address science, society and technology problems with a multi-science perspective integrating the physical, human and health, life and earth sciences. While targeting the needs of all early adolescents, it specifically addresses the needs of urban students. The materials will include software packages and technological tools for gathering, analyzing, and displaying data.

Insights: A Hands-On Elementary Science Curriculum (1991-date under development). Newton, MA: Education Development Center. Distributed by Wings for Learning, Scotts Valley, CA.

K - 6

Insights is an inquiry-based program consisting of thematic modules. When the project is completed, the modules can be used together as a complete curriculum or as individual modules to supplement an existing curriculum. The major organizing themes of systems, change, structure and function, diversity, cause and effect, and energy are infused throughout the modules. Three modules are available as of May 1991: "Myself and Others," "Bones and Skeletons," and "Circuits and Pathways."

Grade Levels

- Intermediate Science Curriculum Study (1966). George Dawson, Director
Tallahassee, FL: Florida State University. Distributed by Silver-
Burdett. 7 - 9

The objectives of ISCS include: developing a comprehensive individualized science program for grades 7-9, providing student materials written in a self-pacing style that includes supplementary "excursion" materials with alternate pathways to follow, building a sequence of science and instruction emphasizing both content and process skills which move from tight structure in grade 7 to open-ended activities in grade 9, developing an Individualized Testing System, and providing Individualized Teacher Preparation Modules. The project utilizes independent study, laboratory investigations, discussions, and self-pacing materials.

- Introductory Physical Science (IPS). Newton, MA: Education Development Center. 8 - 9

The purpose of IPS is to give all students a beginning knowledge of physical science and to offer insight into the means by which scientific knowledge is acquired. IPS employs student experimentation and guided reasoning based on the results of the experimentation. Content includes characteristic properties such as density, solubility, and boiling point; mixtures, pure substances, and elements; radioactivity; and the atomic model.

- Liem, T.L. (1981). Invitations to Science Inquiry. Lexington, MA: Ginn Custom Publishing. 4 - 9

This book is designed for upper elementary and junior high science teachers; its main objective is to help the teachers arouse the students' interest and curiosity. Liem considers discrepant events (occurrences which go against what one thinks is likely) to be one of the best ways to teach science; this book is a collection of experiments which may be considered discrepant events. The book is divided into four sections: Environment, Energy, Space and Forces, and Living Things. Each chapter begins with a list of objectives, followed by the main body, the discrepant events.

- Outdoor Biology Instructional Strategies (OBIS). Berkeley, CA: Lawrence Hall of Science. Distributed by Delta Education, Hudson, NH. 5 - 10

OBIS revolves around ecosystems: natural selection, food chains, species dominance and density, interactions of organisms with their environment, and population structure. The activities are conducted in outdoor settings and employ a variety of strategies, such as games, simulations, craft activities, role playing, experiments, and data analysis. The program consists of twenty-seven modules and is useful for club groups as well as school curriculum.

Grade Levels

Science--A Process Approach (SAPA/SAPAI). Washington, DC: American Association for the Advancement of Science.

K - 6

Focusing on the processes of science rather than content, SAPA and SAPA II introduce basic science skills such as observing, classifying, and measuring in kindergarten then progress through formulating and testing hypotheses, making operational definitions, and analyzing data in grade six. The curriculum is a sequential program that assumes mastery of previous skills. Teacher materials include specific teaching, questioning, and evaluation suggestions.

Science and Technology for Children (STC) (1991-1994). Washington, DC: National Science Resources Center, Distributed by Carolina Biological Supply, Burlington, NC.

1 - 6

STC is a new modular, hands-on science program built around four central themes: observing, measuring and identifying properties; seeking evidence and recognizing patterns and cycles; identifying cause and effect and extending the senses; and designing and conducting experiments. The themes are woven through a sequence of life science, earth science, physical science, and technology units. Three units are available now: plant growth and development, electric circuits, and microworlds. Life cycles of butterflies, experiments with plants, and magnets and motor units are projected for fall 1991; food chemistry and "It's About Time" units are projected for spring 1992. (National Science Resource Center, 1988, p. 144).

Science Curriculum Improvement Study. (SCIS, SCISII, SCIS/85). Berkeley, CA: Lawrence Hall of Science.

K - 6

"In all three stages of its existence, SCIS has focused on the concepts and processes of science for grades K-6. Investigations in life science and physical science build from exploration of materials, through interpretation of information, to application of knowledge and skills to new situations...Sample titles include: Communities, Ecosystems, Environments, Interaction and Systems, Scientific Theories, Populations, and Subsystems and Variables." (National Science Resource Center, 1988).

Grade Levels

Science for Life and Living: Integrating Science, Technology and Health. (1991).
 Colorado Springs, CO: Biological Sciences Curriculum Study. Distributed
 by Kendall/Hunt, Dubuque, IA.

K - 6

Science for Life and Living integrates science as a way of knowing, technology as a way of behaving, and health as a way of behaving. Based on constructivist learning theory, the program presents a five-step instructional plan: engage the learner, explore the concept, explain the concept and define the terms, elaborate on the concept, and evaluate student's understanding of the concept. Cooperative learning along with the social and communication skills it requires is a key feature of this program. Content is organized around a theme for each grade level from K-6: awareness of myself and my world, order and organization, change and measurement, patterns and prediction, systems and analysis, energy and investigation, balance and decisions.

Science Teaching Through its Astronomical Roots (Project STAR) (in development).
 Cambridge, MA: Harvard-Smithsonian Center for Astrophysics.
 Distributed by Learning Technologies., Cambridge, MA.

10 - 12

The complete STAR curriculum including a test, a teacher's guide, and two sets of videos will be available in preliminary edition by August 1991, with a final version to be released in 1992. The STAR activity manual and activity kits are currently available. The activity manual with twenty-one astronomy activities includes hands-on exercises, homework problems, and extension activities. Each activity begins with a section that gives students a chance to explore their own preconceptions or "naive theories" that can become barriers to the understanding of science. The STAR materials and activities then provide opportunities for students to replace their theories with more powerful, accepted ideas.

ScienceVision: A Multimedia Inquiry-Based Science Curriculum (1991).

6 - 9

Developed by the Interactive Media Science (IMS) Project at Florida State University, funded by the National Science Foundation. Distributed by Houghton Mifflin.

Each videodisc in this six disc series contains approximately 50-60 minutes of video and up to 400 still visuals. Through a combination of hardware and software, students are able to conduct experiments, visit locations, hear experts, make decisions, and collect data enabling them to solve the questions posed on the videodisc. Content is presented in two discs per series--life, earth/space, physical. Each disc integrates concepts from the various sciences, and incorporates concepts stressing science, technology, and society.

Grade Levels

Teaching Integrated Mathematics and Science (TIMS), (1991). M/C 250, The
University of Illinois at Chicago, Box 4348, Chicago, IL 60680

1 - 8

TIMS is a curriculum for elementary school students that has been developed at the University of Illinois at Chicago. Howard Goldberg, a physicist, and Philip Wagreich, a mathematician, have worked with teachers to develop more than 80 week-long units. Each unit is an experiment involving drawing pictures, collecting and graphing data and analyzing results. The program is organized around the concept of variables, starting with fundamental variables such as length, area, volume, mass, and time and progressing to more complex variables such as velocity and acceleration. (Salinger, 1991)

C. Research-Oriented Materials

Grade Levels

Cothran, J.H., Giese, R.N., & Rezba, R.J. (1989). Students and Research: Practical Strategies for Science Classrooms and Competitions. Dubuque, IA: Kendall/Hunt Publishing Company.

4 - 12

Students and Research is a manual for teachers providing an extensive curriculum designed to promote scientific literacy via scientific experimentation. Divided into four parts--basic principles of experimental design and analysis, advanced principles of experimental design and analysis, management strategies for classroom and independent research, and strategies for successful science competitions, the authors believe that the necessary skills to develop problem-solving abilities may be gained through implementation of their program. Encompassing product, process, and values as the three aspects of science, the manual attempts not only to provide a broad knowledge base developed through independent investigation, but to frame that knowledge within societal values and expectations of science.

IBM Personal Science Laboratory (PSL). White Plains, NY: International Business Machines.

9 - 12

PSL is a microcomputer-based laboratory that provides measurement probes for temperature, light, distance, and pH (additional probes are under development). The curriculum offers materials for each probe, with demonstrations, explorations and suggested experiments. Computer hardware and software that include math spreadsheets allow students to analyze their experiments.

National Geographic Kids Network (1990-date, in development). Washington, DC: National Geographic.

4 - 6

Using National Geographic Kids Network, students conduct original research, use a computer to record data, and then use a modem and telecommunications to share their findings with "research teammates" across the United States and the world. A National Geographic scientist examines the data online and coaches the students in their study. During the 1990-91 school year, four units were available: "Hello!" "Acid Rain," "What's in Our Water?" and "Weather in Action."

Grade Levels

The Voyage of the Mimi (1984-date) and The Second Voyage of the Mimi. (1989-date). NY: Bank Street College of Education, Distributed by Wings for Learning, Scotts Valley, CA.

4 - 10

The Voyage of the Mimi is a multi-media, interdisciplinary curriculum that centers around a twenty-six part video story of the crew of the 72-foot ketch Mimi and their whale research. Topics covered in the curriculum include whales, maps and navigation, and ecosystems. In addition to the video series, extensive print materials for students and teachers, and computer software with probes support related classroom investigations.

In the second voyage, the Mimi sails off the coast of the Yucatan Peninsula of Mexico where archeologists study the ancient Maya civilization. This curriculum focuses on the Maya civilization, archeology, the Maya base-twenty number system, and the astronomy of the earth and sun.

D. Interdisciplinary and Applied Science

Grade Levels

Bronowski, J. (1973). The Ascent of Man. Boston: Little, Brown and Co.

4 - 9

Jacob Bronowski wrote The Ascent of Man, based on the thirteen part BBC television series. It is a history of science, and examines such developments as an expression of man's special gifts and his unique role in the world. Bronowski begins in prehistoric times, and journeys to modern day. Discoveries range from the flint tool to geometry, from the arch to the theory of relativity; these discoveries show man's developing attempts to control nature. The history takes place in the Western World, in a variety of places including Easter Island, Newton's library, and the Altamira caves. In each location, Bronowski considers man's imagination and how it compelled him to study the physical laws of the world.

Burke, J. (1978). Connections. Boston: Little, Brown and Co.

4 - 9

Connections, written by James Burke, is a companion volume to the television series produced by the BBC and broadcast over the Public Broadcasting Service in 1979. The book is concerned with the changes occurring in the world due to man's use of tools. Eight recent innovations have increased the rate of change. They include: the atomic bomb, the telephone, the computer, the production-line system of manufacture, the aircraft, plastics, the guided rocket, and television. Burke explains how each of these innovations is the result of a sequence of related events, spanning from the beginning of civilization until the present day. Also each innovation may enhance man's future, or may hasten his destruction.

Dunn, S., & Larson, R. (1990). Design Technology: Children's Engineering. NY: Falmer Press.

K - 6

The authors set forth the design technology process as investigation, invention, implementation, and evaluation. They present the major elements or skills of each category as recursive cycles which the student progresses through to resolution. Rather than a curriculum, the book presents a model with the child as engineer and designer that incorporates cooperative learning, the whole language approach to literacy, and inquiry-based approaches in science and math.

Grade Levels

- Iozzi, L.A., & Bastardo, P.J. (1990). Science-Technology-Society: Preparing for Tomorrow's World. Decisions for Today and Tomorrow. Longmont, CO: Sopris West, Inc. 7 - 12

Science-Technology Society is a teaching module divided into three main parts. Part A provides the necessary background information for the successful presentation of the module. Part B contains the specific teaching directions and suggestions for the 12 activities offered. Part C consists of the master copies of the student readings and student activities. The areas of exploration include technological advances, genetic engineering, artificial intelligence, nuclear energy, acid precipitation, hazardous wastes, food and agriculture, organ transplants, transportation, robotics, and technology and decision making.

- Judson, H.F. (1980). The Search for Solutions. NY: Holt, Rinehart & Winston. 6 - 12
(1980 edition is out of print. An abridged edition without illustrations and captions is available from John Hopkins University Press, 1987. Search for Solutions videocassettes are available to schools on free-loan with permission to copy, a free teaching guide is included; contact Karol Media, Wilkes-Barre, PA.)

The Search for Solutions explains in detail how science is done and distinguishes between good science, bad science, and nonsense. Judson incorporates aesthetic criticism in this book, based upon his intimate knowledge of the laboratory. After discussing "The Rage to Know" as the basis for investigation, Judson considers patterns, change, chance, feedback, modeling, strong predictions, evidence, and theory as ways of searching for solutions. He concludes with eight problems in search of solutions, including origins of the universe, evolution, and aging and death.

- LEGO TC Logo. Enfield, CT: Lego Systems. 4 - 8

LEGO TC Logo is an interdisciplinary activity series that can be used to integrate science, mathematics, design, and engineering. By using LEGO blocks as construction material interfaced with a computer and a special version of Logo computer language, children invent, engineer, and operate model machines.

E. Curriculum Resources/References

Grade Levels

Allen, J., Bruce, K., & Tyler, V. (eds.) (1989). Science Experiments on File: Experiments, Demonstrations, and Projects for School and Home. NY: Facts on File, Inc.

6 - 12

Science Experiments on File represents a compilation of earth science, biology, physical science/chemistry, and physics experiments designed for general and advanced students in grades 6 to 12. Representing experiments that function meaningfully in the context of current science curricula, all appear in a standard, concise format; topic, introduction, time and materials needed, safety precautions, procedure and analysis. Especially helpful is a subject index which allows one to narrow a search for an appropriate experiment according to grade level, appropriateness for home or school, time needed, need for adult supervision, and independent/group project. As an added bonus, the entries in this book are self-contained and copyright free.

Blueford, J.R. and others (1985). K-6 Science Curriculum. Reston, VA: Geological Survey (Dept. of Interior and Math Science Nucleus) Freemont, CA.

K - 6

The program is organized into six major cycles that include: science, math, and technology cycle, universe cycle, life cycle, water cycle, plate tectonics cycle, and rock cycle. Each unit is organized by subthemes and contains activities for lower primary grades (K-3) and upper elementary grades (4-6).

Building Tomorrow: Honors Seminar. Vicki Clark, Program Specialist, Mathematics and Science Center, 2401 Hartman Street, Richmond, VA 23223.

8

"The honors seminar for gifted students has been in operation since 1967. The goal of the program is to provide interdisciplinary experiences with an emphasis on scientific topics for students from five different school systems, bringing them together after school. The 'Building Tomorrow' program involved 20 eighth graders. They researched, designed, and built models of futuristic human habitats in the environment of their choice (space, underwater, underground, etc.). Instructors were two science instructors from the Center and an architect from the community. Students used a variety of techniques in developing their projects including library research, written reports, interaction with an architect, script writing, model building, and videotaping." White (1986) p. 122.

Grade Levels

Conceptually Oriented Program in Elementary Science (COPES). New York University.

6 - 12

"COPES is a general elementary science program (K-6) published in the early seventies that focuses on five major conceptual schemes: structural units of the universe, interaction and change, conservation of energy, degradation of energy, and a statistical view of nature. Relationships between lessors in the units are based on these themes, rather than on familiar subject strands." (*Science for Children*, p. 138) Although the curriculum is available only on the SCIENCE HELPER CD-ROM database, it is included here as a resource because of the theme base organization.

Goodstein, M.P. (1983). SCI-MATH: Applications in Proportional Problem-Solving. Menlo Park, CA: Addison-Wesley.

7 - 12

SCI-MATH is intended to help students develop the math skills needed for science, especially dimensional analysis, ratio, and the concept of proportion. Two modules comprise the curriculum. Module one, the pre-algebra module, deals with arithmetic and logic of proportions; module two which uses algebra examines symbolic equations and graphing of proportions. The project was supported by the National Science Foundation.

Grow Lab: Activities for Growing Minds (1990). Burlington, VT: National Gardening Association.

K - 8

Grow Lab offers equipment and supplies for an indoor garden along with a teacher's manual that provides hands-on, inquiry-based lesson plans. The investigations focus on plant growth, life cycles, diversity and adaptation, and the "global garden." Activities in each section of the teacher's manual are coded for grade ranges: K-2; 3-5; 6-8, thereby providing flexibility. Development of the project was supported by the National Science Foundation.

The Growing Classroom: Garden-Based Science (1990). Menlo Park, CA: Addison-Wesley.

K - 6

The Growing Classroom is the curriculum guide for the Life Lab Science Program, a National Diffusion Network program. It provides hands-on or role-playing activities using a garden laboratory in the areas of science, nutrition, and gardening. The project was funded by the National Science Foundation.

Grade Levels

Living in Water (1987). Baltimore, MD: National Aquarium in Baltimore.

4 - 6

Living in Water is a study of water, marine and fresh water environments, and the plants and animals that live in water. Each of five sections addresses a question about water which is then answered by a variety of activities using an experimental, science process approach to enable the students to arrive at answers. The project was supported by the National Science Foundation.

National Aeronautics and Space Administration (NASA).

NASA Teacher Resource Centers (one is located at Langley Research Center in Hampton) provide educators with NASA-related educational materials. The materials, which can be duplicated at the Centers include classroom activities, lesson plans, teacher guides, filmstrips, computer software, laser discs, and audio and video tapes. Also, materials are available for purchase through the Government Printing Office. An example of the materials follows:

Operation Liftoff: Elementary School Space Program. (1987).

This program includes manuals with lesson plans, activities, and background information. The books in the series are titled: Living in Space, Astronomy, Space Transportation, and Space Futures. Topics and activities in Living in Space include food, clothing, health, housing, communication, and working.

NatureScope (1985-date). Washington, DC: National Wildlife Federation.

NatureScope is a science and environmental education activity series that focuses on particular topics such as astronomy, endangered species, oceans, mammals, weather, and wetlands. Each issue of the series includes background information, activities, ready-to-copy activity sheets, and a bibliography.

Rogers, K.B. (Ed.) (1989). The Orno Science Project. Enriched Science for Gifted Cluster Students. Minneapolis, MN: Orono School District.

4 - 8

"This package includes compaction plans, enrichment opportunities designed to be substituted for the basic science curriculum already mastered, and extensive bibliographies of materials and books for gifted students in the Orono (Minnesota) school district." ERIC database

Grade Levels

Saul, W., & Newman, A.R. (1986). Science Fare. NY: Harper & Row.

K - 6

Science Fare is an illustrated catalog of toys, books, and activities for children interested in science. Scientists and children themselves reviewed the toys and activities. This book is for adults who are anxious to attend to their child's natural interests, by providing toys, equipment, and books the child may use to better understand the scientific world. The book also includes discussions of museum programs, clubs and other organizations, recommended books, and where to buy equipment.

The Science Connection (in development). Houston, TX: Houston Museum of Natural Science.

1 - 6

This supplementary program for grades 1-6 is designed to take advantage of basal science textbooks now in broad use. The materials consist of three parts: A Science Discovery Reader, The Science Shoebox Recipe File, and The Science Extension. The materials will offer hands-on activities and will relate the concepts developed to other disciplines. The project is supported by the National Science Foundation and Silver Burdett and Ginn as well as the Houston Museum of Natural Science. (NSF, Summary of Grants, FY 1987-88.)

Sensing the Sea: A Curriculum Guide in Marine Education. (1978). Gloucester Point, VA: Virginia Institute of Marine Science, The College of William and Mary.

K - 3

Resource guides for grades K-1 and 2-3, help students and teachers establish a saltwater aquarium. Activities and experiments enable students to maintain the aquarium and to investigate it as a system. Fishy Activities for Your Small Fry: A Unit Plan in Fish Biology for Grades K-6, also available from the Virginia Institute of Marine Science, offers additional activities and information.

Superscience: A Mass Media Program (in development). NY: Scholastic, Inc.

1 - 6

"The Scholastic, INC. Project, Super Science: A Mass Media Program, will launch two classroom science magazines, one for grades 1-3, another for grades 4-6, with a companion series of computer disk materials. Each will stress hands-on and inquiry activities that mix science with reading, math, and social studies." (NSF, Summary of Grants, FY 1987-88.)

Grade Levels

Virginia's State Parks...Your Backyard Classrooms: Chesapeake Edition. Field Activities Grades K-12. (1990). Gloucester Point, VA: Virginia Institute of Marine Science, The College of William and Mary.

K-12

This resource guide describes state parks in the Chesapeake area and provides activities for studying the parks. Examples of valuable reference materials found in this guide include maps, tidal charts, diagrams of food webs, and a species list and distribution by salinity zones.

A final section of the guide ties activities to Virginia Standards of Learning Objectives.

Windows on Science (1988). Sunnyvale, CA: Creative Publications.

Pre K-2

This hands-on program consists of six resource books that cover topics in life, earth, and physical science. Each resource book contains twenty-eight simple investigations that guide children's thinking. A materials kit is also available.

F. Sources Searched for Science Curriculum Bibliography

ERIC CD-ROM database

Kersh, M.E., Nielsen, M.E., & Subotnik, R.F. (1987). Techniques and sources for developing integrative curriculum for the gifted. Journal for the Education of the Gifted, 11, 56-68.

Lockard, J.D. (Ed.) (1977). Twenty Years of Science and Mathematics Curriculum Development. The Tenth Report of the International Clearinghouse. College Park, MD: University of Maryland, Science Teaching Center.

National Dissemination Study Group (1989). Educational Programs That Work 15 ed. Longmont, CO: Sopris West.

National Science Foundation (March 15, 1989). Summary of Grants, FY 1987-88, Instructional Materials Development Program (draft copy).

National Science Resource Center, Newsletter. Fall 1989, Vol. 2, No. 2-date.

National Science Resource Center (1988). Science for Children: Resources for Teachers. Washington, DC: National Academy Press.

Salinger, G.L. (1991). Materials of physics instruction. Physics Today, 44, 39-45.

White, J.L., & Alamprese, J.A. (1986). Catalogue of Practices in Science and Mathematics Education. Washington, DC: Cosmos Corporation.

Annotations in this bibliography were either written by science curriculum materials review staff, or they were taken from the above sources.